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CONTENTS

Articles

- 1 Notes on the ecology of the oceanic insect *Halobates*, Lanna Cheng
- 8 Chemical and nutritive values of several fresh and canned finfish, crustaceans, and mollusks. Part II. Fatty acid composition, James C. Bonnet, Virginia D. Sidwell, and Elizabeth G. Zook
- 15 Using enzymes to make fish protein concentrates, Malcolm B. Hale
- 19 The Mexican marine sport fisheries, Aurelio Solórzano
- 23 Variable-mesh beach seine for sampling juvenile salmon in Columbia River estuary, Carl W. Sims and Richard A. Johnsen
- 27 Mushroom culture: A new potential for fishery products, John H. Green
- 33 Effect of draining method on the quality of fish stored in boxes, John A. Peters, Allan F. Bezanson, and John H. Green

Departments

- 36 NOAA/NMFS Developments
- 43 Foreign Fishery Developments
- 43 Publications
- 44 Monthly Fishery Market Review
- 48 Editor's Comments

Cover.—The oceanic insect *Halobates* stands on water. Its prey is a wingless *Drosophila*, a small fly. See article by Lanna Cheng, beginning on opposite page.

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Tens of thousands of genera of insects are known on land: there is only one on the sea—Halobates.

Notes on the Ecology of the Oceanic Insect *Halobates*

LANNA CHENG

INTRODUCTION

Members of the genus *Halobates* (Heteroptera: Gerridae) are the only known insects found in the oceans, yet they are among the least studied marine organisms. Although these insects have been known to marine biologists and oceanographers since the early 1800's, nothing much was added to our knowledge of these unique insects until the last 20 years (Cheng, 1972). We now know that there are 39 described species found in the world's oceans, seas, and lagoons (Herring, 1961, 1964).

DISTRIBUTION

Five *Halobates* species are commonly found in the open ocean (Figure 1). All five—*H. micans*, *H. sericeus*, *H. germanus*, *H. splendens*, and *H. sobrinus*—are found in the Pacific Ocean, but only the first two occur also in the Indian Ocean, and only *H. micans* is known from the Atlantic Ocean (Cheng, 1973a). In general they are found in tropical and subtropical waters, their ranges extending from lat. 40° N. to 40° S in the Atlantic (Cheng, 1973b) and the Pacific (Cheng, 1973a, 1973c) but being more restricted in the Indian Ocean (Cheng, 1971). Although the exact factors limiting the distribution of each species are not known, they are certain-

ly related to surface properties of the ocean such as temperature, salinity, surface currents, and winds (Savilov, 1967).

GENERAL BIOLOGY

Our present knowledge of the biology of these oceanic insects is based mainly on casual observations at sea, since attempts to rear them in the laboratory have not been successful so far.

The adults are dark gray or black, with some pale markings on the head and prothorax, almost 5 mm in body length, with a leg spread of about 15 mm (Figure 2). The eggs are laid on any suitable or available floating object, the commonest substrates being pieces of wood, seabird feathers, and tar lumps. They are about 1 mm in length and look rather like miniature rice grains. The newly hatched nymphs, which are also about 1 mm in body length, are light brown in color with characteristic dark brown patterning. There are five nymphal stages before the insects become sexually mature. We do not know how long each stage takes, but laboratory data from rearing closely related freshwater gerrids (Cheng, 1966a) and a near-shore species, *H. hawaiiensis*, (Herring, 1961) suggest that 10-12 days is a reasonable period for each stage. Hence it would require a period of

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about 2 months for the eggs to develop into mature adults. The sexes are not distinguishable until the last nymphal stage.

These insects live exclusively on the surface of the ocean, as they are wingless and cannot fly. Although some earlier workers have reported that *Halobates* can dive, I have not been able to induce them to do so. However, when they are forced under water they can swim for as long as an hour or two. This ability to swim under water is presumably important for the survival of these insects, since in storms they are probably often submerged by waves or spray. Ultimately they must re-surface, before they become waterlogged and drown. For this reason they possess a very effective water-repellent coating of hairs on their body surface, the so-called "plastron" which also helps them to retain a supply of oxygen to enable them to respire when submerged (Cheng, 1973d).

The adults are attracted to light and may be dip-netted easily by using a light lure. When a light trap was used on a raft at the Hawaii Institute of Marine Biology, Coconut Island, in January 1973, the first specimens, all adult males, came to the light after about 10 minutes. The first nymph was caught at the light some 4½ hours after the trap was set up. Adult *Halobates* continued to come to light throughout the night, between 1930 and 0645 hours, at which time it just began to get light.

During a recent expedition to the north central Pacific (South Tow 13) on the R/V *Thomas Washington*, one of the Scripps Institution of Oceanography research fleet, we likewise found that *Halobates* adults arrived within 10 minutes after the ship had arrived on station and the light had

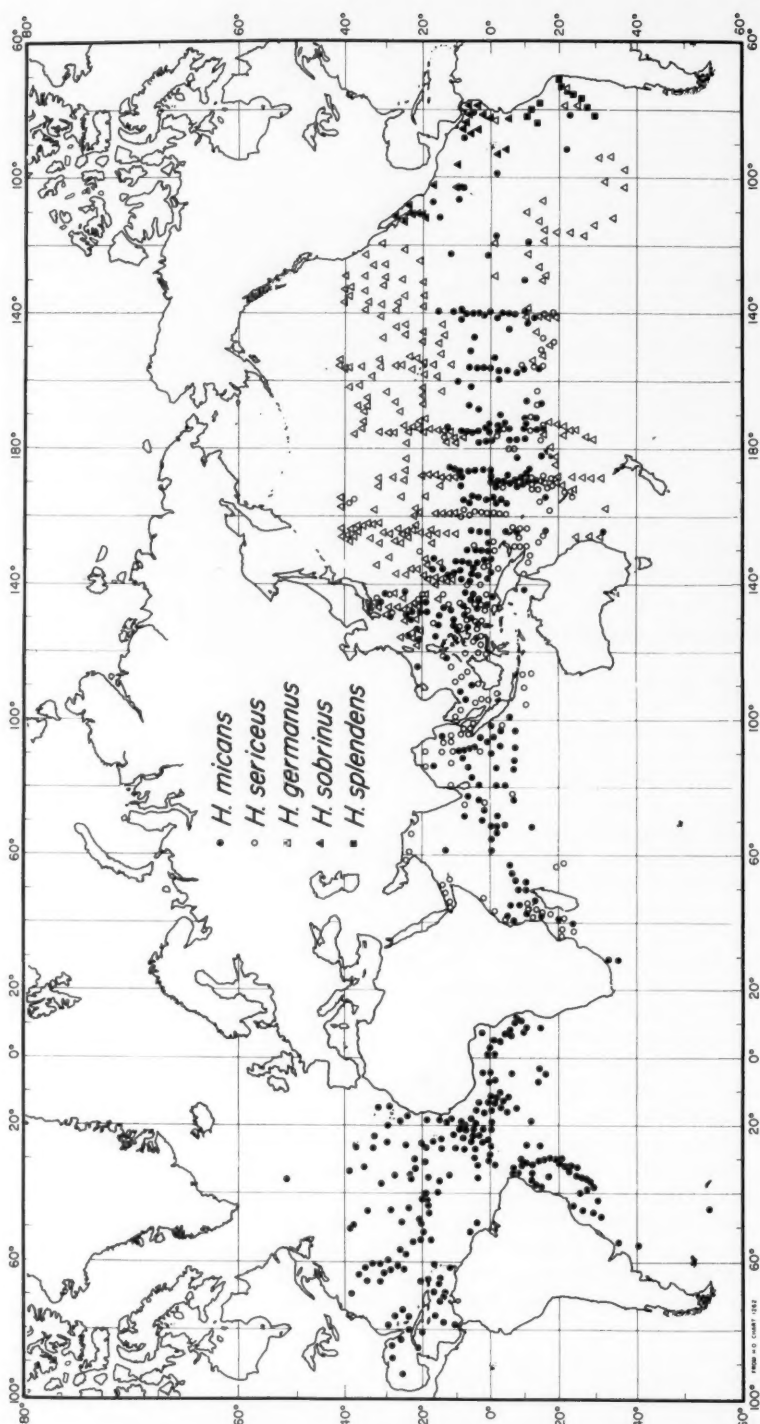


Figure 1.—World distribution of five oceanic *Halobates* species.

been turned on. In this way we collected, during 20-30 min periods in six nights, a total of over 200 adults (from 3 to 108 specimens/night). In these open-ocean collections not a single nymph was caught or observed to come to the light. Since we did not have enough time on station to leave the light trap out for more than 30 minutes, we do not know if some nymphs might eventually have come to the light. We noted that the insects disappeared just before we ourselves could perceive any visible daylight.

Halobates are active and agile insects, and are generally rather difficult to catch. They can skate at a speed of 50-100 cm/sec, or about 1-2 knots. We found evidence that, during the day and on bright moonlit nights, they can see approaching neuston nets, and many can avoid being caught (Cheng, 1973e; Cheng and Enright, 1973). Thus their population densities, calculated from samples collected by slow tows, may be underestimated by a factor which may be as high as 2-3 in daytime samples. These insects are evidently rather common organisms on the sea surface since they were found in at least 20 percent of the EASTROPAC surface samples taken during the daytime in the eastern Pacific Ocean (Cheng, 1973e). We estimate that in some areas of the Pacific their population density may be as high as 0.1/m².

PREDATORS

In the early literature there appear to have been no records of any predators of *Halobates*. Their freshwater relatives, the gerrids, have very few known predators, possibly because of the repellent "buggy" smell of the adults. Newly molted individuals are presumably vulnerable to insectivorous fish, amphibians, and other insects, and cannibalism has been observed among the nymphs of the freshwater *Metrocoris*, though not among adults (Cheng, 1966a). However, adult

Figure 3.—Localities from which sea-bird stomach samples were collected.

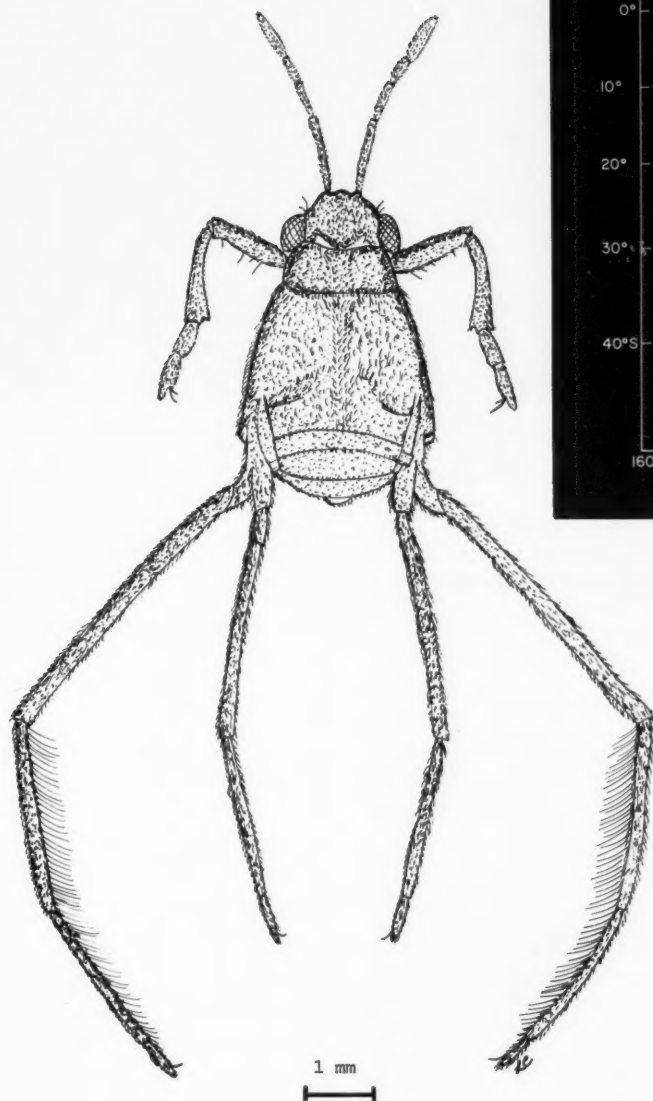
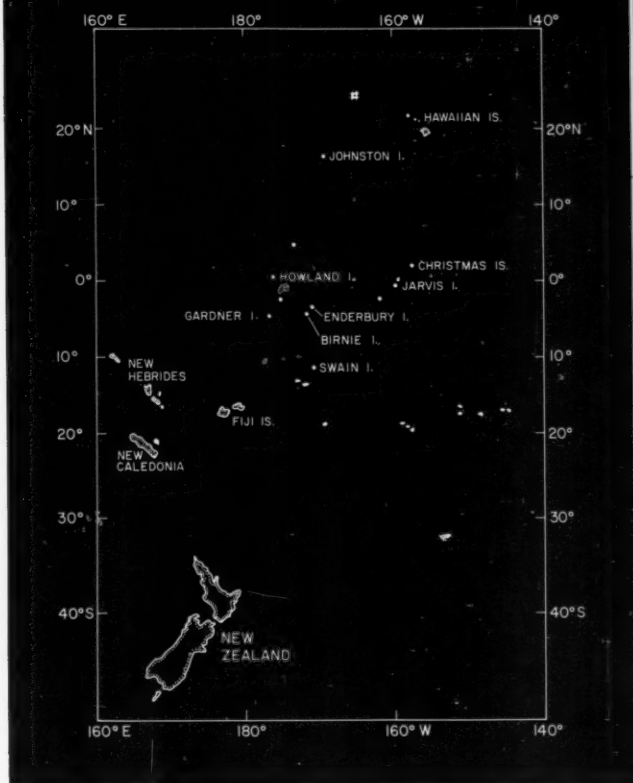


Figure 2.—*Halobates micans*, adult female.



Halobates were observed to feed on one another when numbers were kept without food in an aquarium on board the R/V *Thomas Washington*.

The only definitive published record of predators of *Halobates* is one by Ashmole and Ashmole (1967), who carried out a very detailed study on the feeding ecology of seabirds of Christmas Island (a small tropical island in the central Pacific), and recorded these insects in the stomach contents of two (out of eight examined) species of surface-feeding seabirds, the blue-grey noddy, *Procelsterna cerulea*, and the Phoenix petrel, *Pterodroma alba*. Although fish and squid formed the main bulk of their food, *Halobates* was found to be quite an important component of their diet. In a total of 95 samples of regurgitated food from *Pt. alba*, *Halobates* was found in 11 samples, though it constituted less than 0.5 percent of the total volume of food. Among 34 *P. cerulea* samples studied, 23 contained remains of *Halobates*, which in this case constituted as much as 7 percent by volume.

I recently obtained from the Smithsonian Institution 20 samples of stomachs belonging to three species of surface-feeding seabirds, the white tern *Gygis alba*, *Procelsterna cerulea*, and *Pterodroma alba*, all collected during the Smithsonian Pacific Ocean Biological Survey Program in 1966 (Table 1). The samples came from a rather wide area of the Pacific Ocean, extending roughly between lat. 25°N to 20°S and long. 150°W to 180°W, well within the distribution range of at least three oceanic species of *Halobates* (Figure 3). Most of the stomachs were found to be almost empty or contained only a few unidentified fragments of partially digested food. However, *Halobates* was found in five samples of *P. cerulea*, corroborating the earlier report by Ashmole and Ashmole (1967). Four of the stomach samples came from birds collected in an area several hundred miles northwest of the Hawaiian Islands, and the remaining one came from Enderbury

Island, together with one sample of *Gygis alba* which contained no recognizable *Halobates* remains. Two of these stomachs contained only well digested *Halobates* remains, but the heavily cuticularized legs are easily recognizable by their black color. In two other samples, the insects' bodies, too, were still recognizable, while in the fifth sample some of the *Halobates* specimens were still intact. (Since the sample size was so small no attempt was made to estimate the proportional volume of insects in the food of these seabirds.)

Dissections of adult *Halobates*, collected alive, have shown that their body cavity is often filled with orange-colored lipids, suggesting that they may be a rich source of food for surface-feeding fishes. However, the stomachs of several fishes (*Centrobrachus brevirostris*, *C. choerocephalus*, and *Cymbolophorus* sp.), caught in neuston nets together with *Halobates* in the North Pacific Gyre (lat. 28°N, long. 155°W), contained no insect remains. *Halobates* remains have been found in a young Pacific anchovy (Dr. A. S. Loukashkin, California Academy of Sciences, San Francisco; personal communication) and also in the stomach of a *Sardinella siim* collected in Jakarta Bay (Dr. M. Hutomo, Institute of Marine Research, Jakarta; personal communication). In both cases they were initially considered to be aerial contaminants. I hope that in the future more of our colleagues will report any insects which they may find in fish stomachs, so that we may learn more about *Halobates*' predators.

PREY

Halobates have been reported to associate with pelagic coelenterates such as the Portuguese man-of-war, *Physalia*; the by-the-wind-sailor, *Velella*; and the jellyfish, *Porpita*, presumably feeding on these common surface marine animals. It seems unlikely that they could live by feeding exclusively on these animals, which

consist of about 90 percent seawater. On a recent expedition to the North Pacific, various organisms collected in the neuston tows or dip-netted from the surface water were offered to the *Halobates* kept in an aquarium on board the ship. These insects were never seen to feed on *Physalia*, *Velella*, or *Porpita*. They were, however, observed to feed on pontellid copepods, hyperiid amphipods, euphausiids, and myctophid larvae trapped on the surface film. How often such animals become caught in this way is not known, but I found many small animals could be caught by simply pouring the contents of a plankton haul from one beaker to another, and presumably surf and spray could have the same effect in nature. It is also very likely that *Halobates* could feed on floating fish eggs, which, during some seasons, are found in great abundance in tropical and subtropical waters. Unfortunately, suitable fish eggs were not available for feeding experiments during the recent expedition. The insects

Table 1.—Collecting data on seabird stomach samples.

Species	Field Number	Date	Locality	Halobates
<i>Gygis alba</i>				
	5872	18 Feb 66	11°03'S 171°06'W Swain I.	—
	5873	18 Feb 66	11°03'S 171°06'W Swain I.	—
	5874	18 Feb 66	11°03'S 171°06'W Swain I.	—
	5876	18 Feb 66	11°03'S 171°06'W Swain I.	—
	0528	26 Apr 66	20°N 158°W Hawaiian Is.	—
	6580	26 Jul 66	04°40'S 174°31'W Gardner I.	—
	2387	6 Aug 66	02°29'S 162°30'W	—
	6638	7 Aug 66	00°15'S 159°55'W Jarvis I.	—
	6693	10 Sep 66	16°45'N 169°32'W Johnston I.	—
	5726	16 Sep 66	03°08'S 171°05'W Enderbury I.	—
<i>Procelsterna cerulea</i>				
	1794	26 Feb 66	02°39'S 175°21'W	—
	2234	8 Jun 66	23°20'N 164°40'W	+
	2236	8 Jun 66	23°21'N 164°43'W	+
	2237	8 Jun 66	23°24'N 164°52'W	+
	2238	8 Jun 66	23°28'N 164°59'W	+
	6686	17 Aug 66	00°48'N 176°38'W Howland I.	—
	6731	26 Sep 66	03°08'S 171°05'W Enderbury I.	+
	6765	11 Oct 66	03°35'S 171°32'W Birnie I.	—
	6766	11 Oct 66	03°35'S 171°32'W Birnie I.	—
<i>Pterodroma alba</i>				
	2414	20 Aug 66	04°59'N 173°22'W	—

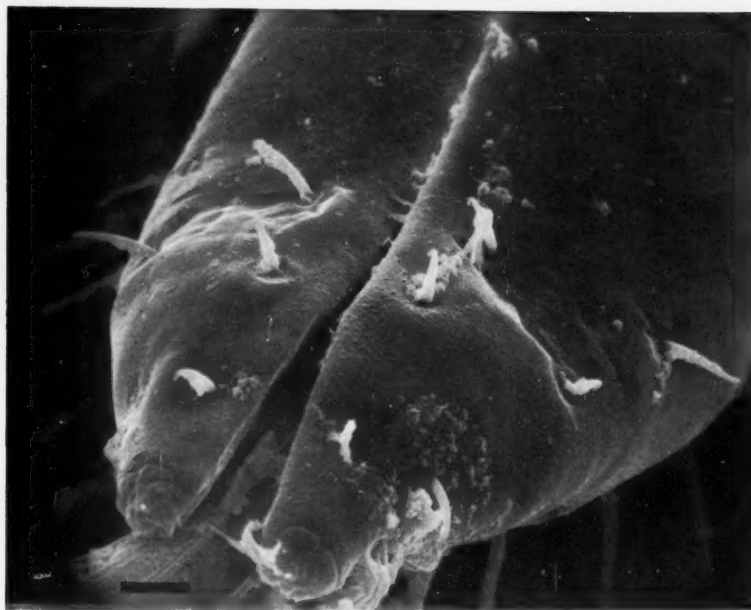


Figure 4.—Tip of rostrum (Scanning Electron Micrograph) (Scale = 10 μ).

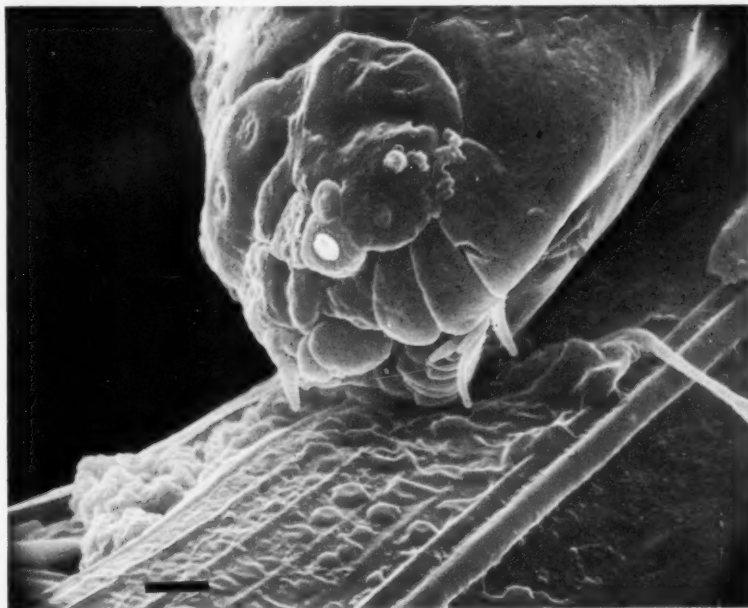
have not been observed to dive underwater to catch prey, even when potential prey was swimming directly underneath them.

The mouthparts of *Halobates* are of the classical hemipteran type. The rostrum or beak consists of a four-segmented sheath, enclosing a pair of serrated mandibles and a pair of long maxillae or stylets. It is usually held in a horizontal position, tucked under the head, but when the animal is feeding it is swung forward and held perpendicular to the longitudinal axis of the body. Its tip is equipped with sensory papillae and hairs (Figures 4 and 5) which are presumably responsible for locating suitable spots for penetrating the body of the prey. The mandibles, which are only slightly longer than the rostrum, flank the paired maxillae, and serve to pierce the body wall of the prey. The inner maxillary surfaces are lined with hairs which hold the edges of the two stylets together to form the feeding tube (Figures 6 and 7). The food is liquified by

salivary enzymes injected into the prey via the salivary canal and then sucked up via the food canal, much in the same way as in other gerrids (Cheng, 1966b).

When *Halobates* is feeding it holds its prey with its front legs. If the prey is relatively small it is held well above the water surface, the insect assuming a rigid "standing" position during the entire feeding period (see cover), which may last from 5 to 20 minutes. If the prey is relatively large, such as a fish larva 1-2 cm long, the insect merely grasps it; in such cases, more than one insect may feed simultaneously on the same victim. The "standing" feeding position is presumably an adaptation for avoiding competition, since these insects may detect food by the surface ripples created by a struggling organism in the same way as their freshwater relatives (Murphy, 1971), and lifting it off the sea surface eliminates such ripples. This standing position, with the antennae held in an upright position and the body supported on the tips of the mid- and hind tarsi, is very different from the usual "resting" position of these insects, in which

Figure 5.—Tip of rostrum, showing sensory hairs and papillae (SEM) (Scale = 2 μ).



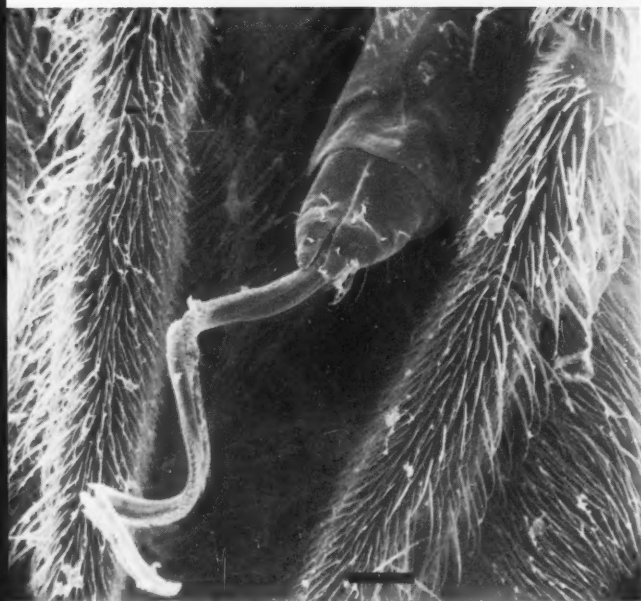


Figure 6.—Third and fourth segment of rostrum ensheathing maxillary stylets (SEM) (Scale = 50 μ).

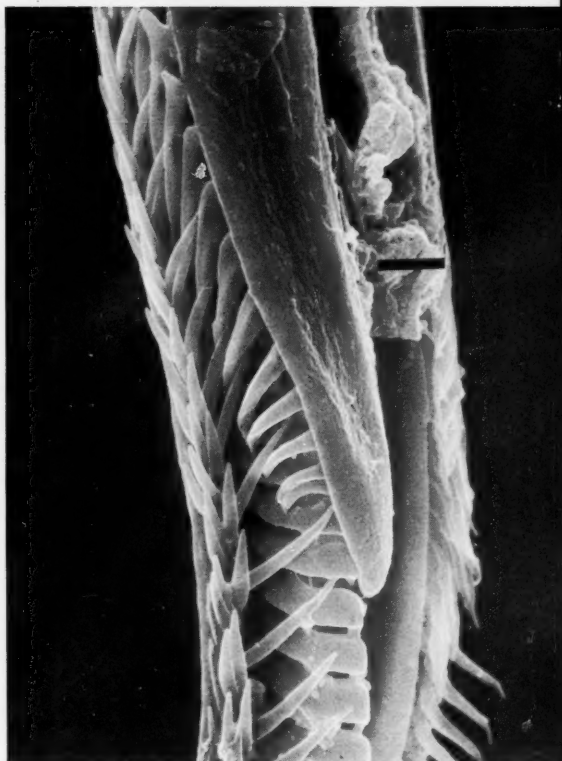


Figure 7.—Hairs on inner surface of maxillary stylet (SEM) (Scale = 5 μ).



Figure 8.—*Halobates* in resting position.

Figure 9.—Top view of resting *Halobates*.

the antennae are held in front of the head and the legs are well spread out (Figures 8 and 9).

CONCLUSION

Organisms of the ocean surface have received very little attention in marine biological studies. Even the taxonomy of such common animals as *Physalia* and *Velella* has yet to be resolved (Savilov, 1968). Our knowledge of the biology of animals occupying this special stratum of the ocean and of their roles in the food web is still only fragmentary. Eggs and larvae of several species of fish are found exclusively in this layer. This is also where air-borne pollutants and other contaminants first come into contact with the ocean. Since the surface of the ocean is thus potentially of considerable economic and ecological importance, it is essential for us to study and understand better the animals living in this stratum, including, as one of the top predators of this ecosystem, that enigmatic insect, *Halobates*.

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Research determines fatty acid composition of 32 commonly eaten finfish, crustaceans, and mollusks.

Chemical and Nutritive Values of Several Fresh and Canned Finfish, Crustaceans, and Mollusks. Part II. Fatty Acid Composition

JAMES C. BONNET, VIRGINIA D. SIDWELL,
and ELIZABETH G. ZOOK

ABSTRACT

This paper presents data on total fat and fatty acid composition of 32 commonly eaten finfish, crustaceans, and mollusks. Among these are two canned finfish, salmon, tuna in oil and tuna in brine; the other samples were raw.

INTRODUCTION

Although there have been a number of studies carried out on the fatty acids in fish, very little has been done on the edible flesh of common market fish in the United States. Ackman (1967) has reported on some species of both freshwater and marine fish of North America; Krzeczowski, Tenney, and Hayes (1972) have reported on some of the mollusks; and Stansby and Hall (1967) have also done some work in the area of commercially important fish in the United States. Much of the other fatty acid data available at present covers fish components which are not edible portions—liver, roe, milt, etc.

The object of this study was to provide total fat and the fatty acid composition of commonly marketed finfish, both fresh and canned, crustaceans,

James C. Bonnet, Virginia D. Sidwell, and Elizabeth G. Zook are members of the staff of the College Park Fishery Products Technology Laboratory, National Marine Fisheries Service, NOAA, College Park, MD 20740.

and mollusks. Since this report is an interim report for fatty acids, the values for some of the fatty acids may change somewhat as more data are added to the compilation.

ANALYTICAL PROCEDURE

Samples

The sampling technique is described by Zook et al.¹

Total Fat

The total fat was determined on edible muscle by the method developed by Smith, Ambrose, and Knobl (1964).

Preparation of Esters

Methyl esters were prepared using the method of Gauglitz and Lehman (1963). Amounts of reactants were scaled down for use with smaller sample size, about 0.5 gram. The esters were separated and identified using

¹ Zook, E., J. Powell, B. Hackley, J. Emerson, J. Brooker, and G. M. Knobl, Jr. Survey for selected heavy metal content of consumer available fish. In preparation.

Table 1.—Common and scientific names of the fish and shellfish used in this study.

Common name	Scientific name
Finfish	
Calfish	<i>Ictalurus punctatus</i>
Cod	<i>Gadus morhua</i>
Flounder, yellowtail	<i>Limanda ferruginea</i>
Haddock	<i>Melanogrammus aeglefinus</i>
Hake	<i>Merluccius productus</i>
Halibut	<i>Hippoglossus stenolepis</i>
Perch	<i>Sebastes marinus</i>
Pollock	<i>Pollachius virens</i>
Rockfish	<i>Sebastes spp.</i>
Snapper	<i>Lutjanus campechanus</i>
Whiting	<i>Merluccius bilinearis</i>
Canned	
Salmon	<i>Oncorhynchus nerka</i>
Tuna	<i>Thunnus albacares</i>
Crustaceans	
Blue crab	<i>Callinectes sapidus</i>
King crab	<i>Paralithodes camtschatica</i>
Lobster, spiny	<i>Panulirus argus</i>
Shrimp, brown	<i>Penaeus aztecus</i>
Shrimp, Maine	<i>Pandalus borealis</i>
Shrimp, Mexican	Mixed species
Shrimp, white	<i>Penaeus setiferus</i>
Mollusks	
Clam, hard	<i>Mercenaria mercenaria</i>
Clam, soft	<i>Mya arenaria</i>
Clam, surf	<i>Spisula solidissima</i>
Oyster	<i>Crassostrea virginica</i>
Scallops, bay	<i>Pecten sp.</i>
Scallops, calico	<i>Argopecten gibbus</i>
Scallops, sea	<i>Placopecten magellanicus</i>

Gelman's² ITLC silica gel chromatography media and ultraviolet light, then extracted from the media with petroleum ether. The petroleum ether was removed by vacuum distillation and the esters were analyzed by GLC.

Chromatographic Conditions

The Hewlett-Packard 810 GC used was equipped with dual flame ionization detectors and an 8 ft × 1/4 in pyrex column packed with 5 percent diethylene-glycol succinate on 80/100 mesh Chromosorb W (HP).

The helium carrier gas flow rate was 60 ml/min; hydrogen flow rate, 45 ml/min; air flow rate, 300 ml/min; column temperature programmed from 140°C to 210°C at 1° per minute; detector temperature, 235°C; and injection temperature 285°C.

RESULTS AND DISCUSSIONS

Table 1 lists the common and scientific names of the finfish, fresh and canned, mollusks and crustaceans.

All 13 species of the fresh finfish

² Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

fall into the low fat classification, ranging from the low of 0.35 percent in the Icelandic cod to a high of 4.86 percent in the halibut. The tuna, canned in vegetable oil, contained the highest level of total fat. The one canned in brine was markedly lower. The canned salmon was the only finfish that falls in the category of high fat fish. The mollusks and crustaceans have low total fat contents. The total fat content levels found in Table 2 contain not only the fatty acids, but also steroids, phospholipids, triglycerides, and many other fat-like substances.

The fatty acid composition of the finfish is tabulated in Table 3. The range for each fatty acid is quite wide. The differences are due primarily to the physiological status of the fish. The diet and the age of the fish are also contributing factors. The data presented in Table 3 may be used to compare the composition of the various fish, but not to determine the actual amount of a certain fatty acid, since the composition of the total fat was not determined.

The percent of unsaturated fatty acids ranges from a low of 58 percent in wild catfish to a high of 81 percent in ocean perch. There is a significant difference between the cultured and wild catfish, probably caused by the differences in the diets of the fish.

As may be noted in Table 4, the tuna canned in oil contained more unsaturated fats than the one in brine, 88 percent and 79 percent respectively, which may have been due to the vegetable oil that was used in the processing.

On these limited data recorded in Table 5, there appears to be very little difference in the fatty acid composition of the different crustaceans. The saturated fatty acids ranged from a low of 15 percent in Maine shrimp to

Table 2.—Total fat content of finfish, fresh and canned, crustaceans and mollusks.

	Mean & standard error of mean	Range	Number of analyses
Percent of sample			
Finfish			
Catfish, cultured	1.48 ± 0.18	1.10—2.61	10
Catfish, wild	1.80 ± 0.21	1.15—2.65	7
Cod, Icelandic	0.67 ± 0.06	0.35—0.98	10
Cod, domestic	0.65 ± 0.05	0.36—0.81	8
Flounder, yellowtail	1.20 ± 0.07	0.94—1.52	10
Haddock	0.65 ± 0.03	0.42—0.77	12
Hake, Pacific	1.48 ± 0.19	0.93—2.01	6
Halibut	2.33 ± 0.25	1.36—4.86	18
Perch, ocean	1.67 ± 0.09	0.99—2.32	20
Pollock	1.03 ± 0.04	0.94—1.13	5
Rockfish	1.38 ± 0.12	0.79—2.18	14
Snapper, red	1.19 ± 0.12	0.67—2.30	19
Whiting	3.80 ± 0.49	2.28—4.86	6
Canned finfish			
Salmon	6.73 ± 0.25	6.08—7.33	5
Tuna (in oil)	14.49 ± 0.65	12.28—15.72	6
Tuna (in brine)	1.38 ± 0.10	0.99—1.61	7
Crustaceans			
Crab, blue	1.88 ± 0.08	1.33—2.47	14
Crab, king			
body meat	1.27 ± 0.05	0.94—1.40	8
leg meat	1.73 ± 0.15	1.27—2.23	6
Lobster, spiny	1.20 ± 0.03	1.03—1.33	14
Shrimp, brown, Texas	1.19 ± 0.01	1.14—1.24	7
Shrimp, Maine	1.32 ± 0.08	1.05—1.60	8
Shrimp, Mexican	1.07 ± 0.03	0.80—1.24	18
Shrimp, white, Gulf	1.18 ± 0.02	1.00—1.36	20
Shrimp, white, So. Atl.	1.22 ± 0.03	1.08—1.34	8
Mollusks			
Clam, hard	0.38 ± 0.02	0.24—0.47	8
Clam, soft	2.18 ± 0.33	1.03—3.03	7
Clam, surf	0.88 ± 0.05	0.74—1.18	9
Oyster, Long Island	1.93 ± 0.11	1.64—2.54	10
Oyster, Chesapeake	1.57 ± 0.06	1.30—1.83	10
Scallop, bay	0.84 ± 0.02	0.75—0.90	12
Scallop, calico	0.89 ± 0.02	0.83—0.95	8
Scallop, sea	1.05 ± 0.02	0.95—1.11	6

a high of 27.5 percent in the coastal white shrimp.

In Table 6 it may be observed that the mollusks tended to be a little higher in saturated fatty acids, 17.5 percent in sea scallops and 41.5 percent in Long Island oysters, than the crustaceans. Also the oysters and clams showed a higher percentage of non-identifiable fatty acids than the scallops.

SUMMARY

This paper presents the total fat and fatty acid composition of finfish, fresh and canned, crustaceans and mollusks.

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Table 3.—Fatty acid composition of raw finfish.

Acid: No. double bonds	Catfish, cultured	Catfish, wild	Cod, Icelandic	Cod, inshore (domestic)	Flounder, yellowtail	Haddock, inshore (domestic)	Hake, Pacific	Halibut	Perch, ocean	Pol- lock	Rockfish	Snapper, red	Whiting
							Percent total fatty acids						
14:0	11.33 ± 0.23 20.75 ± 3.02	13.04 ± 0.23 20.03 ± 3.02	0.40 ± 0.12 0.83 ± 0.12	0.74 ± 0.12 0.43 ± 0.12	12.60 ± 1.83 23.47 ± 3.47	0.95 ± 0.14 0.44 ± 0.14	11.78 ± 0.71 22.15 ± 3.19	12.83 ± 0.16 11.85 ± 3.89	14.42 ± 0.38 2.06 ± 6.56	0.73	1.91 ± 0.42 0.94 ± 0.31	3.06 ± 0.65 10.54 ± 3.23	4.97 ± 0.69 6.78 ± 3.23
15:0	0.62 ± 0.09 0.41 ± 1.19	0.83 ± 0.26 0.83 ± 0.26	0.19 ± 0.09 0.19 ± 0.09	0.69 ± 0.45 0.69 ± 0.45	0.82 ± 0.18 0.32 ± 0.32	0.51 ± 0.14 0.27 ± 0.27	0.14 ± 0.07 0.45 ± 0.45	0.31 ± 0.02 0.48 ± 0.48	0.34 ± 0.02 0.20 ± 0.44	0.23	0.23 ± 0.03 0.16 ± 0.09	0.71 ± 0.16 0.28 ± 0.28	0.55 ± 0.04 2.76 ± 0.68
16:0	10.51 ± 0.79 6.28 ± 13.81	20.77 ± 3.66 10.45 ± 26.65	2.26 ± 14.86 9.00 ± 24.00	12.35 ± 30.24 12.35 ± 30.24	16.22 ± 22.18 10.46 ± 22.18	17.13 ± 2.91 7.48 ± 26.50	13.05 ± 0.53 12.09 ± 13.91	10.28 ± 0.76 6.50 ± 19.14	8.43 ± 0.44 5.76 ± 10.71	11.12	11.57 ± 1.25 8.15 ± 24.66	14.29 ± 1.20 8.38 ± 19.66	15.04 ± 1.78 9.53 ± 18.33
17:0	1.23 ± 0.10 0.83 ± 1.61	1.48 ± 0.15 1.17 ± 1.89	1.12 ± 0.09 0.82 ± 1.35	0.70 ± 0.23 0.23 ± 0.23	2.04 ± 0.27 1.21 ± 1.31	1.38 ± 0.29 0.78 ± 0.67	0.08 ± 0.08 0.08 ± 0.08	0.83 ± 0.06 0.34 ± 1.08	0.54 ± 0.05 0.36 ± 1.02	0.70	1.23 ± 0.18 0.54 ± 2.20	1.44 ± 0.18 0.79 ± 3.36	0.53 ± 0.04 0.42 ± 0.65
18:0	5.43 ± 0.51 0.33 ± 7.20	4.30 ± 0.51 2.19 ± 7.16	10.94 ± 2.80 6.38 ± 23.63	7.31 ± 1.68 5.00 ± 15.65	7.36 ± 0.96 4.52 ± 10.61	6.84 ± 1.43 2.12 ± 11.09	2.37 ± 0.27 1.84 ± 2.75	2.41 ± 0.33 1.37 ± 1.90	2.32 ± 0.09 1.30 ± 3.36	5.67	3.66 ± 0.51 2.00 ± 8.67	7.56 ± 0.81 3.28 ± 12.20	2.61 ± 0.65 1.07 ± 4.40
19:00	0.33 ± 0.08 0.00 ± 0.78	—	0.11 ± 0.11 0.00 ± 0.64	0.05 ± 0.34 0.00 ± 0.34	0.79 ± 0.18 0.31 ± 1.38	0.43 ± 0.15 0.00 ± 0.84	1.50 ± 0.40 0.85 ± 2.22	0.54 ± 0.06 0.82 ± 0.91	0.28 ± 0.07 0.00 ± 0.91	0.29	0.54 ± 0.07 0.25 ± 0.92	0.25 ± 0.07 0.00 ± 0.64	0.64 ± 0.11 0.41 ± 1.07
20:0	0.19 ± 0.10 0.00 ± 0.69	2.86 ± 1.01 0.00 ± 4.49	—	—	0.56 ± 0.21 0.00 ± 1.38	0.14 ± 0.09 0.00 ± 0.44	1.05 ± 0.06 0.95 ± 1.15	0.08 ± 0.32 0.00 ± 0.86	0.34 ± 0.08 0.00 ± 0.78	0.40	0.20 ± 0.06 0.00 ± 0.43	0.23 ± 0.11 0.00 ± 1.38	0.64 ± 0.27 0.00 ± 1.29
24:0	0.26 ± 0.17 0.00 ± 1.21	0.20 ± 0.20 0.00 ± 0.80	0.84 ± 0.84 0.00 ± 5.04	—	0.27 ± 0.27 0.00 ± 1.64	0.05 ± 0.05 0.32 ± 0.32	0.35 ± 0.35 1.05 ± 1.05	0.80 ± 0.17 1.88 ± 0.49	0.03 ± 0.03 0.00 ± 0.49	—	0.23 ± 0.16 0.00 ± 1.58	—	—
14:1	0.20 ± 0.05 0.06 ± 0.52	0.81 ± 0.17 0.52 ± 1.29	0.52 ± 0.27 0.20 ± 1.33	0.08 ± 0.16 0.00 ± 0.16	0.38 ± 0.09 0.09 ± 0.09	0.25 ± 0.10 0.06 ± 0.06	0.10 ± 0.04 0.12 ± 0.26	0.02 ± 0.02 0.08 ± 0.35	0.24 ± 0.00 0.11 ± 0.45	0.12	0.09 ± 0.01 0.06 ± 0.17	0.21 ± 0.05 0.04 ± 0.75	0.23 ± 0.04 0.11 ± 0.33
15:1	0.18 ± 0.03 0.08 ± 0.39	0.64 ± 0.14 0.28 ± 0.86	0.14 ± 0.46 0.14 ± 1.50	0.09 ± 0.23 0.00 ± 0.23	0.35 ± 0.05 0.51 ± 0.81	0.33 ± 0.19 0.00 ± 1.07	0.10 ± 0.02 0.14 ± 0.19	0.02 ± 0.03 0.09 ± 0.44	0.16 ± 0.01 0.11 ± 0.28	0.10	0.13 ± 0.02 0.06 ± 0.23	0.18 ± 0.03 0.03 ± 0.44	0.17 ± 0.03 0.12 ± 0.26
16:1	4.46 ± 0.48 3.22 ± 6.53	7.38 ± 1.83 2.30 ± 10.56	1.83 ± 1.83 1.28 ± 9.56	1.18 ± 2.99 1.19 ± 9.44	3.75 ± 0.64 4.91 ± 9.66	3.27 ± 1.26 1.72 ± 5.76	6.97 ± 1.19 5.49 ± 9.33	5.63 ± 0.91 5.25 ± 10.86	5.63 ± 0.91 2.96 ± 14.79	11.59	5.60 ± 0.57 3.26 ± 10.67	5.51 ± 0.52 2.02 ± 7.81	8.61 ± 0.34 7.71 ± 9.38
17:1	0.09 ± 0.09 0.00 ± 0.85	0.26 ± 0.26 0.00 ± 1.05	0.20 ± 0.21 0.00 ± 1.19	0.35 ± 0.08 0.00 ± 0.55	0.81 ± 1.11 0.00 ± 0.55	0.23 ± 0.18 0.00 ± 1.09	0.57 ± 0.07 1.71 ± 1.71	0.46 ± 0.09 0.86 ± 0.86	0.41 ± 0.07 0.00 ± 0.88	0.29	0.28 ± 0.08 0.00 ± 0.71	0.45 ± 0.12 0.00 ± 1.35	0.42 ± 0.22 0.00 ± 0.93
18:1ω9	12.63 ± 2.23 6.79 ± 23.90	22.45 ± 6.37 3.58 ± 31.64	13.20 ± 1.68 9.52 ± 19.17	14.18 ± 2.53 3.62 ± 31.64	11.11 ± 1.08 7.85 ± 15.34	13.22 ± 4.31 9.87 ± 25.99	12.22 ± 1.58 10.50 ± 15.38	17.49 ± 1.00 11.13 ± 27.69	13.15 ± 0.49 9.04 ± 15.26	8.88	15.91 ± 1.37 9.04 ± 26.14	15.12 ± 0.88 9.87 ± 23.96	16.79 ± 2.35 10.41 ± 22.55
20:1	1.30 ± 0.37 0.00 ± 3.23	1.14 ± 0.67 0.00 ± 3.23	4.81 ± 1.39 0.00 ± 10.35	3.13 ± 0.93 0.00 ± 5.79	2.70 ± 0.34 1.62 ± 3.47	1.74 ± 0.38 0.68 ± 3.04	1.94 ± 0.39 1.24 ± 2.57	6.06 ± 1.33 18.29 ± 14.92	7.00 ± 1.37 0.00 ± 14.92	2.96	1.62 ± 0.30 0.00 ± 3.79	1.89 ± 0.27 0.57 ± 3.49	3.37 ± 0.72 1.66 ± 4.99
22:1	0.04 ± 0.03 0.00 ± 0.18	—	—	0.09 ± 0.09 0.00 ± 0.52	0.08 ± 0.08 0.00 ± 0.49	—	—	—	0.16 ± 0.11 0.00 ± 1.45	11.33	0.35 ± 0.13 0.00 ± 1.16	—	0.45 ± 0.27 0.00 ± 1.13
18:2ω9	2.25 ± 0.83 0.00 ± 6.62	5.54 ± 1.30 1.89 ± 7.80	2.25 ± 1.02 0.00 ± 6.65	1.02 ± 0.32 0.00 ± 1.32	0.24 ± 0.24 0.00 ± 1.44	1.23 ± 0.40 0.00 ± 2.98	1.64 ± 0.07 1.51 ± 1.74	1.12 ± 0.07 0.68 ± 1.49	1.23 ± 0.11 9.00 ± 2.14	0.94	1.40 ± 0.11 0.81 ± 1.88	1.26 ± 0.19 0.39 ± 2.50	1.74 ± 0.06 1.61 ± 1.93
18:2ω6	0.54 ± 0.14 0.00 ± 1.23	0.27 ± 0.27 0.00 ± 1.07	0.24 ± 0.16 0.00 ± 0.87	0.05 ± 0.38 0.00 ± 0.38	0.54 ± 0.12 0.00 ± 1.29	0.62 ± 0.27 0.00 ± 1.83	0.44 ± 0.08 0.31 ± 0.58	0.46 ± 0.04 0.23 ± 0.82	0.35 ± 0.08 0.00 ± 1.47	0.21	0.33 ± 0.07 0.00 ± 0.81	0.39 ± 0.05 0.00 ± 0.77	0.39 ± 0.06 0.30 ± 0.59
20:2ω9	0.33 ± 0.17 0.00 ± 1.10	0.27 ± 0.27 0.00 ± 1.06	0.14 ± 0.09 0.00 ± 0.53	0.15 ± 0.08 0.00 ± 0.39	0.92 ± 0.18 0.57 ± 1.45	0.18 ± 0.09 0.00 ± 0.46	0.38 ± 0.19 0.00 ± 0.57	0.33 ± 0.05 0.00 ± 0.66	0.20 ± 0.04 0.00 ± 0.40	0.48	0.17 ± 0.04 0.00 ± 0.38	0.44 ± 0.08 0.00 ± 1.05	0.32 ± 0.16 0.00 ± 0.85
20:2ω6	0.67 ± 0.17 0.00 ± 1.31	—	—	0.26 ± 0.10 0.00 ± 0.58	0.64 ± 0.06 0.00 ± 0.82	0.07 ± 0.07 0.00 ± 0.43	0.22 ± 0.11 0.00 ± 0.36	0.16 ± 0.04 0.50 ± 0.65	0.13 ± 0.05 0.00 ± 0.65	0.85	0.07 ± 0.04 0.00 ± 0.30	0.12 ± 0.05 0.00 ± 0.45	0.09 ± 0.06 0.00 ± 0.25
18:3ω3	1.16 ± 0.44 0.00 ± 3.37	0.51 ± 0.31 0.00 ± 1.24	0.72 ± 0.72 0.00 ± 4.32	—	0.90 ± 0.41 2.08 ± 0.00	0.52 ± 0.37 0.00 ± 2.23	2.19 ± 1.35 5.18 ± 5.18	3.45 ± 1.14 9.35 ± 13.42	5.29 ± 1.56 0.00 ± 13.42	—	1.12 ± 0.35 0.00 ± 3.67	0.42 ± 0.25 0.00 ± 2.96	3.87 ± 2.02 0.00 ± 8.86
20:3ω9	0.24 ± 0.08 0.00 ± 0.59	0.19 ± 0.19 0.00 ± 0.77	0.08 ± 0.05 0.00 ± 0.31	0.18 ± 0.08 0.00 ± 0.44	0.34 ± 0.08 0.00 ± 0.95	0.11 ± 0.05 0.00 ± 0.24	0.06 ± 0.06 0.23 ± 0.43	0.14 ± 0.03 0.00 ± 0.28	0.07 ± 0.02 0.00 ± 0.25	0.21	0.10 ± 0.03 0.00 ± 0.21	0.30 ± 0.05 0.00 ± 0.76	0.11 ± 0.05 0.00 ± 0.20
20:3ω6	0.06 ± 0.04 0.00 ± 0.26	—	0.07 ± 0.07 0.00 ± 0.44	0.06 ± 0.04 0.00 ± 0.21	0.04 ± 0.04 0.00 ± 0.25	0.04 ± 0.04 0.00 ± 0.23	—	1.19 ± 0.39 0.00 ± 4.27	0.06 ± 0.04 0.00 ± 0.44	—	1.08 ± 0.61 0.00 ± 6.00	0.08 ± 0.03 0.00 ± 0.33	0.28 ± 0.17 0.00 ± 0.72
20:4ω6 & 20:3ω3	5.68 ± 0.21 4.47 ± 6.41	2.29 ± 0.75 1.05 ± 4.29	6.04 ± 1.59 2.38 ± 11.07	4.10 ± 0.97 0.00 ± 6.71	2.93 ± 0.59 0.66 ± 5.01	3.25 ± 0.47 1.68 ± 4.61	1.89 ± 0.43 1.32 ± 2.73	6.42 ± 0.47 3.22 ± 9.84	14.95 ± 2.15 0.93 ± 29.78	2.33	2.39 ± 0.40 0.40 ± 4.72	3.83 ± 0.34 1.52 ± 7.49	7.17 ± 1.94 1.88 ± 11.90

Table 3.—Fatty acid composition of raw finfish, continued.

Acid. No. double bonds	Catfish, cultured	Catfish, wild	Cod Icelandic	Cod inshore (domestic)	Flounder, yellowtail	Haddock, inshore (domestic)	Hake, Pacific	Halibut	Perch, ocean	Pol- lock	Rockfish	Snapper, red	Whiting
Percent total fatty acids													
18:4 ω 3	0.36 \pm 0.03	4.02 \pm 3.82	0.00 \pm 0.46	0.17 \pm 0.08	1.70 \pm 0.63	0.48 \pm 0.16	1.57 \pm 0.89	1.89 \pm 0.61	1.73 \pm 0.66	0.66	1.82 \pm 0.75	0.83 \pm 0.27	2.41 \pm 0.70
	0.27 \pm 0.53	0.00 \pm 15.46	0.00 \pm 2.74	0.00 \pm 0.40	0.91 \pm 4.80	0.00 \pm 1.14	0.00 \pm 3.09	0.41 \pm 6.52	0.31 \pm 8.67		0.17 \pm 7.62	0.27 \pm 4.30	1.11 \pm 4.31
20:4 ω 3	0.92 \pm 0.15	0.19 \pm 0.19	1.48 \pm 0.48	0.52 \pm 0.11	1.52 \pm 0.35	1.89 \pm 0.65	1.45 \pm 0.28	0.79 \pm 0.13	3.83 \pm 1.77	*1.06	0.95 \pm 0.27	0.82 \pm 0.09	0.54 \pm 0.23
	0.46 \pm 1.72	0.00 \pm 0.76	0.00 \pm 2.72	0.00 \pm 0.78	0.85 \pm 3.21	0.48 \pm 4.80	0.95 \pm 1.91	0.00 \pm 1.65	0.00 \pm 17.3		0.00 \pm 2.73	0.26 \pm 1.44	0.00 \pm 1.11
22:4 ω 6	1.22 \pm 0.07	3.65 \pm 2.37	2.65 \pm 0.55	1.11 \pm 0.25	1.59 \pm 0.24	1.76 \pm 0.27	0.98 \pm 0.20	2.27 \pm 0.32	2.26 \pm 0.25	*0.54	1.34 \pm 0.15	2.00 \pm 0.17	1.73 \pm 0.05
	0.96 \pm 1.57	0.00 \pm 10.74	1.55 \pm 4.74	0.00 \pm 1.73	1.13 \pm 2.75	0.95 \pm 2.63	0.59 \pm 1.21	0.74 \pm 4.46	0.64 \pm 3.28		0.63 \pm 1.96	0.62 \pm 2.96	0.81 \pm 1.81
20:5 ω 3	15.54 \pm 2.73	0.73 \pm 0.28	9.21 \pm 2.55	8.32 \pm 1.67	10.89 \pm 2.56	9.62 \pm 2.08	16.49 \pm 1.76	3.14 \pm 0.35	4.82 \pm 0.26	*9.41	13.33 \pm 1.12	4.68 \pm 0.79	9.18 \pm 2.26
	7.31 \pm 24.28	0.00 \pm 1.25	1.39 \pm 16.24	0.00 \pm 10.60	1.29 \pm 19.61	2.24 \pm 14.31	13.11 \pm 19.02	0.00 \pm 13.63	2.50 \pm 6.30		4.58 \pm 18.51	0.87 \pm 13.09	5.14 \pm 17.44
22:5 ω 6	1.77 \pm 0.20	—	0.70 \pm 0.28	0.89 \pm 0.18	1.02 \pm 0.25	1.80 \pm 0.48	1.32 \pm 0.26	1.27 \pm 0.25	0.84 \pm 0.19	*1.17	1.07 \pm 0.21	2.63 \pm 0.23	0.46 \pm 0.20
	1.27 \pm 2.81	—	0.00 \pm 1.60	0.00 \pm 1.18	0.00 \pm 1.95	0.00 \pm 3.50	0.52 \pm 1.69	0.00 \pm 3.26	0.00 \pm 1.24		0.00 \pm 2.40	1.02 \pm 4.02	0.00 \pm 0.91
22:5 ω 3	3.67 \pm 0.48	3.69 \pm 2.99	2.11 \pm 0.66	1.57 \pm 0.37	3.86 \pm 0.71	2.21 \pm 0.38	1.85 \pm 0.17	3.62 \pm 0.14	1.04 \pm 0.07	*1.81	2.86 \pm 0.23	3.76 \pm 0.36	1.24 \pm 0.24
	2.04 \pm 5.91	0.00 \pm 12.64	0.00 \pm 5.04	0.00 \pm 2.81	1.59 \pm 5.82	1.02 \pm 3.71	1.33 \pm 1.93	2.52 \pm 4.36	0.53 \pm 1.76		1.81 \pm 4.13	0.23 \pm 5.31	0.64 \pm 2.08
22:6 ω 3	23.45 \pm 3.05	4.65 \pm 3.61	15.47 \pm 5.04	28.59 \pm 6.62	11.48 \pm 3.47	24.74 \pm 6.52	17.11 \pm 5.39	15.01 \pm 1.01	17.72 \pm 1.32	*46.58	25.64 \pm 2.74	23.90 \pm 3.01	12.49 \pm 2.79
	9.55 \pm 35.86	0.00 \pm 15.42	2.63 \pm 36.38	0.00 \pm 46.47	1.86 \pm 24.76	6.09 \pm 44.20	8.57 \pm 27.08	9.79 \pm 22.38	6.64 \pm 27.22		19.13 \pm 38.37	0.75 \pm 47.70	7.97 \pm 22.99
Total	3.30 \pm 0.50	7.76 \pm 1.55	4.38 \pm 2.59	3.39 \pm 1.36	4.95 \pm 1.18	3.89 \pm 0.82	7.35 \pm 1.98	2.21 \pm 0.22	2.00 \pm 0.14	*1.20	3.02 \pm 0.77	2.96 \pm 0.53	2.75 \pm 0.28
Unknown	1.86 \pm 6.87	4.92 \pm 11.16	1.06 \pm 17.16	0.68 \pm 9.31	1.31 \pm 7.83	1.47 \pm 7.07	3.41 \pm 9.63	1.30 \pm 3.77	1.16 \pm 3.23		1.14 \pm 9.49	0.59 \pm 6.96	2.08 \pm 3.48
No. of analyses	9	4	6	6	6	6	3	15	16	2	12	14	5

* Insufficient data available at present for a statistical analysis.

† Mean \pm standard error of mean.

‡ Range of analytical values.

Table 4.—Fatty acid composition of canned finfish.

Acid. No. double bonds	Salmon, red (canned)	Tuna, yellowfin (canned in oil)	Tuna, yellowfin (canned in brine)
Percent of total fatty acids			
14:0	12.45 \pm 0.31 †1.66 \pm 3.18	10.42 \pm 0.05 ‡0.28 \pm 0.59	11.68 \pm 0.59 ‡0.54 \pm 3.63
15:0	0.31 \pm 0.02 0.26 \pm 0.37	0.14 \pm 0.02 0.08 \pm 0.18	0.55 \pm 0.14 0.25 \pm 0.98
16:0	8.50 \pm 0.21 8.05 \pm 9.04	6.78 \pm 0.28 5.93 \pm 7.67	9.30 \pm 1.12 6.50 \pm 12.86
17:0	0.79 \pm 0.05 0.67 \pm 0.91	0.42 \pm 0.04 0.26 \pm 0.58	1.52 \pm 0.28 0.82 \pm 2.42
18:0	1.28 \pm 0.25 0.55 \pm 1.65	3.54 \pm 0.21 2.89 \pm 4.31	4.79 \pm 0.89 3.52 \pm 8.31
19:0	0.60 \pm 0.04 0.53 \pm 0.64	—	0.48 \pm 0.02 0.42 \pm 0.55
20:0	0.79 \pm 0.26 0.00 \pm 1.13	—	0.18 \pm 0.18 0.00 \pm 0.89
24:0	—	—	—
14:1	0.16 \pm 0.01 0.14 \pm 0.19	0.02 \pm 0.01 0.00 \pm 0.06	0.13 \pm 0.03 0.06 \pm 0.21
15:1	0.09 \pm 0.00 0.08 \pm 0.09	0.10 \pm 0.02 0.05 \pm 0.19	0.13 \pm 0.03 0.07 \pm 0.26
16:1	3.83 \pm 0.35 3.20 \pm 4.81	1.06 \pm 0.15 0.69 \pm 1.53	3.85 \pm 0.92 1.54 \pm 5.90
17:1	0.39 \pm 0.05 0.24 \pm 0.48	—	—
18:1 ω 9	12.29 \pm 0.28 11.69 \pm 12.88	13.66 \pm 0.42 11.82 \pm 14.93	9.68 \pm 0.91 6.32 \pm 11.78
20:1	0.93 \pm 0.58 0.00 \pm 14.85	1.93 \pm 1.10 0.00 \pm 6.17	1.40 \pm 0.18 0.89 \pm 1.93
22:1	0.65 \pm 0.65 0.00 \pm 2.61	—	—
18:2 ω 9	2.06 \pm 0.16 1.78 \pm 2.43	—	1.69 \pm 0.28 1.07 \pm 2.42
18:2 ω 6	0.39 \pm 0.02 0.34 \pm 0.44	31.18 \pm 1.28 27.53 \pm 34.52	0.39 \pm 0.02 0.36 \pm 0.44
20:2 ω 9	0.16 \pm 0.16 0.00 \pm 0.85	0.25 \pm 0.08 0.00 \pm 0.51	0.32 \pm 0.19 0.15 \pm 0.66
20:2 ω 6	0.42 \pm 0.11 0.26 \pm 0.75	—	0.24 \pm 0.16 0.00 \pm 0.75
18:3 ω 3	6.75 \pm 3.53 0.00 \pm 12.91	1.74 \pm 1.11 0.00 \pm 5.23	0.63 \pm 0.19 0.39 \pm 1.00
20:3 ω 9	0.33 \pm 0.03 0.27 \pm 0.40	0.08 \pm 0.05 0.00 \pm 0.24	0.37 \pm 0.02 0.31 \pm 0.41
20:3 ω 6	0.54 \pm 0.22 0.00 \pm 0.90	—	0.49 \pm 0.42 0.00 \pm 2.17
20:4 ω 6 & 20:3 ω 3	7.78 \pm 3.89 1.04 \pm 14.87	3.71 \pm 0.34 2.70 \pm 4.93	6.69 \pm 1.55 3.58 \pm 11.49
18:4 ω 3	1.24 \pm 0.69 0.55 \pm 2.62	1.93 \pm 1.22 0.00 \pm 6.15	1.00 \pm 0.16 0.56 \pm 1.38
20:4 ω 3	5.37 \pm 3.14 0.00 \pm 11.91	0.51 \pm 0.13 0.00 \pm 0.85	0.84 \pm 0.13 0.61 \pm 1.31
22:4 ω 6	0.81 \pm 0.07 0.72 \pm 1.01	0.72 \pm 0.07 0.49 \pm 0.98	1.52 \pm 0.41 0.89 \pm 3.10
20:5 ω 3	10.09 \pm 0.33 9.14 \pm 10.70	4.56 \pm 1.11 2.26 \pm 8.49	12.59 \pm 1.11 10.88 \pm 16.97
22:5 ω 6	2.67 \pm 0.35 1.65 \pm 3.18	1.97 \pm 0.23 1.57 \pm 3.06	3.33 \pm 0.08 3.05 \pm 3.48
22:5 ω 3	3.51 \pm 0.16 3.17 \pm 3.92	1.16 \pm 0.14 0.77 \pm 1.70	2.66 \pm 0.22 2.14 \pm 3.18
22:6 ω 3	16.44 \pm 1.66 14.31 \pm 21.36	23.26 \pm 1.78 17.10 \pm 29.27	32.34 \pm 7.02 14.26 \pm 49.55
Total	2.17 \pm 0.74	0.84 \pm 0.19	2.92 \pm 0.55
Unknown	1.31 \pm 4.39	0.47 \pm 1.76	1.45 \pm 3.90
No. of analyses	4	6	5

† Mean \pm standard error of mean.

‡ Range of analytical values.

Table 6.—Fatty acid composition of raw mollusks.

Acid. No. double bonds	Clam, hard	Clam, soft	Clam, surf	Oyster (Long Island)	Oyster (Md.-Va.)	Scallop, bay	Scallop, calico	Scallop, sea
Percent of total fatty acids								
14:0	12.16 ± 0.41 11.22 — 3.22	12.19 ± 0.40 11.00 — 2.64	12.28 ± 0.39 11.27 — 3.56	18.13 ± 1.66 13.93 — 13.84	13.39 ± 0.50 11.67 — 4.39	12.45 ± 0.42 11.28 — 4.03	12.61 ± 0.60 10.69 — 4.20	13.16 ± 0.96 12.13 — 5.09
15:0	1.38 ± 0.25 0.71 — 1.81	1.15 ± 0.12 0.80 — 1.31	1.07 ± 0.23 0.51 — 1.84	1.45 ± 0.24 0.80 — 1.97	0.91 ± 0.10 0.52 — 1.08	0.71 ± 0.11 0.38 — 1.07	0.71 ± 0.06 0.51 — 0.88	0.72 ± 0.08 0.56 — 0.85
16:0	8.78 ± 1.72 4.91 — 12.62	12.46 ± 3.60 4.85 — 20.98	8.26 ± 1.21 5.37 — 12.65	22.43 ± 2.99 12.64 — 30.31	18.31 ± 0.61 17.01 — 20.54	8.29 ± 0.75 5.30 — 10.11	10.63 ± 0.93 7.09 — 12.43	9.99 ± 2.54 5.52 — 14.32
17:0	1.92 ± 0.25 1.32 — 2.36	1.37 ± 0.26 0.79 — 1.94	1.39 ± 0.29 0.49 — 2.19	1.78 ± 0.21 1.45 — 2.61	1.29 ± 0.11 1.06 — 1.68	0.72 ± 0.11 0.37 — 1.00	0.76 ± 0.09 0.44 — 0.99	0.67 ± 0.14 0.40 — 0.87
18:0	4.08 ± 0.76 2.79 — 5.74	3.03 ± 0.63 1.87 — 4.33	2.87 ± 0.49 1.65 — 4.61	3.45 ± 0.43 2.20 — 4.73	1.92 ± 0.20 1.54 — 2.61	2.19 ± 0.49 1.15 — 4.31	2.62 ± 1.36 0.00 — 6.90	2.02 ± 0.49 1.07 — 2.70
19:0	0.74 ± 0.74 0.00 — 2.97	0.17 ± 0.17 0.00 — 0.69	0.10 ± 0.10 0.00 — 0.51	0.37 ± 0.15 0.00 — 0.64	0.57 ± 0.13 0.36 — 1.08	0.34 ± 0.21 0.00 — 1.15	0.19 ± 0.11 0.00 — 0.58	0.28 ± 0.14 0.00 — 0.44
20:0	2.70 ± 1.19 0.00 — 5.46	0.75 ± 0.44 0.00 — 1.67	0.07 ± 0.07 0.00 — 0.34	1.43 ± 0.13 1.11 — 1.86	1.72 ± 0.45 0.00 — 2.62	0.83 ± 0.17 0.05 — 1.26	0.19 ± 0.16 0.00 — 0.80	0.48 ± 0.32 0.00 — 1.09
24:0	—	—	2.28 ± 1.62 0.00 — 8.28	0.43 ± 0.43 0.00 — 2.17	—	1.25 ± 0.59 0.00 — 3.34	2.42 ± 0.72 0.00 — 3.74	—
14:1	1.12 ± 0.23 0.50 — 1.59	0.90 ± 0.22 0.25 — 1.18	0.81 ± 0.22 0.19 — 1.53	0.49 ± 0.11 0.23 — 0.88	0.45 ± 0.06 0.22 — 0.57	0.41 ± 0.12 0.04 — 0.73	0.17 ± 0.05 0.04 — 0.33	0.28 ± 0.08 0.19 — 0.45
15:1	1.44 ± 0.25 0.77 — 1.90	1.12 ± 0.25 0.39 — 1.48	0.94 ± 0.25 0.24 — 1.80	0.45 ± 0.13 0.22 — 0.89	0.30 ± 0.05 0.16 — 0.48	0.51 ± 0.12 0.09 — 0.81	0.15 ± 0.04 0.05 — 0.31	0.30 ± 0.09 0.19 — 0.47
16:1	3.07 ± 0.21 2.62 — 3.50	4.48 ± 1.01 2.72 — 7.22	3.06 ± 0.22 2.51 — 3.75	4.31 ± 0.41 3.22 — 5.43	2.83 ± 0.30 1.62 — 3.24	3.14 ± 0.24 2.34 — 4.13	2.14 ± 0.09 1.86 — 2.34	3.11 ± 1.43 1.58 — 5.97
17:1	3.06 ± 1.22 1.33 — 6.64	1.32 ± 0.34 0.48 — 2.01	0.74 ± 0.37 0.00 — 1.93	0.85 ± 0.14 0.58 — 1.22	0.67 ± 0.10 0.49 — 1.06	0.44 ± 0.20 0.00 — 0.91	1.96 ± 1.05 0.00 — 4.44	0.23 ± 0.11 0.00 — 0.37
18:1 _{n-9}	5.31 ± 1.65 3.42 — 10.25	6.22 ± 1.25 4.50 — 9.93	5.04 ± 1.04 3.04 — 8.73	4.63 ± 0.51 3.06 — 5.55	3.81 ± 0.16 3.43 — 4.36	3.70 ± 0.49 2.38 — 5.56	2.96 ± 0.40 1.53 — 3.98	3.34 ± 1.32 1.42 — 5.88
20:1	1.21 ± 0.71 0.00 — 2.77	1.10 ± 0.83 0.00 — 3.49	3.69 ± 0.81 0.67 — 5.53	2.39 ± 0.33 1.82 — 3.60	2.13 ± 0.41 1.31 — 3.51	2.89 ± 1.63 0.00 — 10.83	1.22 ± 0.23 0.47 — 1.92	1.51 ± 0.43 0.97 — 2.35
22:1	—	0.68 ± 0.68 0.00 — 2.72	—	—	0.40 ± 0.40 0.00 — 1.98	0.19 ± 0.19 0.00 — 1.11	—	—
18:2 _{n-9}	2.75 ± 0.18 2.35 — 3.18	1.18 ± 0.41 0.00 — 1.78	0.99 ± 0.45 0.00 — 2.29	1.35 ± 0.14 0.95 — 1.76	2.13 ± 0.18 2.00 — 2.71	1.38 ± 0.51 0.00 — 3.73	0.69 ± 0.06 0.54 ± 0.89	0.84 ± 0.11 0.62 — 0.97
18:2 _{n-6}	0.75 ± 0.75 0.00 — 3.00	0.72 ± 0.49 0.00 — 2.09	1.85 ± 0.34 0.67 — 2.77	0.85 ± 0.16 0.56 — 1.33	0.59 ± 0.13 0.36 — 1.08	0.87 ± 0.14 0.35 — 1.38	0.51 ± 0.12 0.28 — 0.91	0.62 ± 0.14 0.45 — 0.89
20:2 _{n-9}	1.77 ± 0.70 0.00 — 3.34	1.13 ± 0.46 0.00 — 2.09	—	0.32 ± 0.13 0.00 — 0.62	2.26 ± 0.66 0.55 — 4.23	0.54 ± 0.19 0.00 — 1.04	0.16 ± 0.10 0.00 — 0.40	0.73 ± 0.37 0.00 — 1.13
20:2 _{n-6}	0.55 ± 0.55 0.00 — 2.18	0.11 ± 0.11 0.00 — 0.42	0.42 ± 0.42 0.00 — 2.08	0.46 ± 0.05 0.37 — 0.55	0.53 ± 0.15 0.00 — 0.89	0.17 ± 0.11 0.00 — 0.57	0.35 ± 0.18 0.00 — 0.95	0.83 ± 0.05 0.72 — 0.89
18:3 _{n-3}	2.62 ± 0.36 1.96 — 3.38	1.40 ± 0.59 0.00 — 2.82	0.65 ± 0.49 0.00 — 2.55	2.57 ± 0.41 1.79 — 4.05	0.49 ± 0.49 0.00 — 2.45	0.92 ± 0.34 0.00 — 2.13	0.10 ± 0.10 0.00 — 0.52	0.58 ± 0.29 0.00 — 0.93
20:3 _{n-9}	0.99 ± 0.65 0.00 — 2.74	0.75 ± 0.62 0.00 — 2.58	1.24 ± 0.74 0.00 — 3.85	0.52 ± 0.20 0.00 — 1.20	0.39 ± 0.12 0.00 — 0.69	1.40 ± 0.54 0.59 — 4.07	0.49 ± 0.13 0.30 — 1.02	0.18 ± 0.18 0.00 — 0.53

Table 6.—Fatty acid composition of raw mollusks, continued.

Acid No. double bonds	Clam, hard	Clam, soft	Clam, surf	Oyster (Long Island)	Oyster (Md.-Va.)	Scallop, bay	Scallop, calico	Scallop, sea
	Percent of total fatty acids							
20:3 ω 6	—	—	0.03 \pm 0.03 0.00 — 0.17	0.16 \pm 0.16 0.00 — 0.79	0.29 \pm 0.14 0.00 — 0.72	0.38 \pm 0.18 0.00 — 0.89	—	0.20 \pm 0.20 0.00 — 0.60
20:4 ω 6	3.99 \pm 0.39 3.07 — 4.77	4.38 \pm 0.88 2.87 — 6.65	4.22 \pm 0.37 3.30 — 5.53	1.73 \pm 0.20 0.98 — 2.15	2.12 \pm 0.31 1.41 — 3.22	6.77 \pm 3.10 2.74 — 22.17	6.82 \pm 0.35 5.89 — 7.96	3.13 \pm 0.24 2.66 — 3.43
18:4 ω 3	4.62 \pm 1.31 2.31 — 8.34	1.82 \pm 1.04 0.00 — 4.61	2.67 \pm 0.64 0.55 — 4.44	4.23 \pm 0.96 1.41 — 7.37	5.83 \pm 0.59 4.27 — 7.43	2.36 \pm 0.64 0.84 — 5.17	1.45 \pm 0.30 0.67 — 2.36	4.37 \pm 0.92 3.20 — 6.18
20:4 ω 3	3.51 \pm 1.62 0.00 — 7.76	1.24 \pm 0.54 0.00 — 2.54	2.81 \pm 1.32 0.00 — 4.63	1.14 \pm 0.26 0.62 — 1.83	1.55 \pm 0.40 0.88 — 3.00	1.82 \pm 0.92 0.59 — 6.38	0.74 \pm 0.14 0.39 — 1.18	1.75 \pm 0.12 1.53 — 1.94
22:4 ω 6	5.61 \pm 1.33 2.82 — 8.83	3.79 \pm 0.92 1.52 — 6.00	5.98 \pm 1.32 1.65 — 9.16	1.83 \pm 0.35 1.14 — 3.14	1.76 \pm 0.44 0.81 — 3.44	3.10 \pm 0.84 0.00 — 6.26	2.26 \pm 0.19 1.76 — 2.75	3.02 \pm 0.31 2.59 — 3.63
20:5 ω 3	4.45 \pm 1.22 1.73 — 7.67	11.22 \pm 5.57 4.56 — 27.84	11.41 \pm 7.69 0.00 — 41.82	7.58 \pm 1.87 2.32 — 12.60	12.17 \pm 0.98 9.61 — 15.00	19.33 \pm 4.81 0.00 — 36.88	21.73 \pm 1.99 19.14 — 29.64	20.59 \pm 5.26 10.86 — 28.93
22:5 ω 6	—	0.50 \pm 0.31 0.00 — 1.27	3.30 \pm 2.02 0.00 — 10.04	0.54 \pm 0.22 0.00 — 1.02	1.53 \pm 0.33 0.54 — 2.49	1.92 \pm 0.14 1.23 — 2.15	2.98 \pm 0.19 2.36 — 3.42	1.89 \pm 0.23 1.46 — 2.23
22:5 ω 3	4.02 \pm 1.02 1.37 — 6.34	3.88 \pm 1.15 1.50 — 7.68	6.91 \pm 1.84 2.05 — 11.19	1.56 \pm 0.37 0.94 — 3.02	1.68 \pm 0.44 0.56 — 3.21	3.90 \pm 0.31 2.90 — 4.71	3.32 \pm 0.23 2.80 — 4.03	2.48 \pm 0.03 2.44 — 2.54
22:6 ω 3	5.06 \pm 1.24 1.48 — 7.06	13.35 \pm 2.16 9.13 — 17.38	11.49 \pm 2.05 5.49 — 17.94	5.17 \pm 1.06 1.81 — 7.46	15.59 \pm 1.63 10.89 — 18.93	21.55 \pm 1.66 14.37 — 26.21	27.09 \pm 2.07 19.59 — 30.97	27.52 \pm 3.11 21.53 — 31.95
Total Unknown	23.89 \pm 4.28 16.04 — 36.09	17.15 \pm 3.04 8.78 — 23.19	13.18 \pm 4.30 2.41 — 26.72	17.36 \pm 1.40 13.63 — 20.92	12.09 \pm 1.72 8.16 — 17.96	5.54 \pm 1.24 0.72 — 9.47	2.58 \pm 1.65 0.33 — 9.04	5.17 \pm 0.91 3.57 — 6.73
No. of analyses	4	4	5	5	5	6	5	3

* Mean \pm standard error of mean.

* Range of analytical values.

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An enzymatic FPC process could make profitable use of some of our underutilized or latent resources.

Using Enzymes to Make Fish Protein Concentrates

MALCOLM B. HALE

ABSTRACT

Fish protein concentrates having desirable functional properties can be prepared by using selected enzymes to solubilize protein and release lipids. An enzymatic FPC process could make profitable use of some of our underutilized or latent resources.

The relative activities of 23 commercially available proteolytic enzyme preparations acting on a fish protein substrate were measured. Pancreatin, pepsin, and papain had highest activity per unit cost of enzyme.

*Soluble hydrolysates were prepared from red hake (*Urophycis chuss*) using a variety of enzyme and digestion conditions. Concentrations of the amino acids tryptophan and histidine in the soluble products were critical nutritionally and varied with the pH of hydrolysis. A soluble FPC having a protein efficiency ratio equal to that of casein was prepared with an alkaline bacterial enzyme at pH 8.5.*

Production costs have been estimated for a soluble product prepared from whole fish and a partially soluble product prepared from presscake through the use of enzymes.

INTRODUCTION

Fish protein concentrates (FPC's) are made by processes which concentrate fish protein into a more stable form. As a form of animal protein, FPC's can supplement vegetable proteins very effectively. Added in low concentrations they can markedly improve the nutritive value of bread and many other common foods by supplying certain essential amino acids deficient in vegetable proteins. Produced from species of fish not normally used as food, they are an inexpensive source of animal protein and could provide a profitable use for some of our presently underutilized or latent resources.

FPC's may be produced by various processes to give products with different costs and properties, thus different applications. Most of these processes are described in a recently compiled bibliography published by the Library of Congress (1970). Most of the processing methods can be classified as chemical (solvent extraction) or biological (enzymatic and microbial) procedures. During recent years most efforts have involved the use of sol-

vents, usually isopropyl alcohol, and several pilot plants and a few full-scale industrial plants have been constructed (Ernst, 1971). By solvent extraction FPC can be produced that is a bland, nearly odorless, lightly-colored, water-insoluble, but highly nutritive powder. FPC's prepared by biological procedures are usually more flavorful and may have desirable functional properties. In general the biological procedures have not advanced beyond the laboratory or small pilot plant stage.

THE BIOLOGICAL METHOD

The work described in this paper has been called the "Biological Method" within the fish protein concentrate (FPC) program of the National Marine Fisheries Service. Biological processing studies at the College Park Fishery Products Technology Laboratory have been concentrated on the use of proteolytic enzymes to prepare soluble hydrolysates of fish protein.

Fish proteins are complex molecules consisting of chains of simpler molecules called amino acids linked together by peptide bonds. Proteolytic enzymes are also proteins and are structured in such a way that they act as catalysts in the breakage of peptide bonds by a process called hydrolysis. Most of the shorter amino acid chains broken off from the fish protein are water-soluble. Fish lipids (fat) are also released from the tissue during hydrolysis and can be physically separated by centrifugation.

The enzyme systems employed in fish protein hydrolysis may be either the natural enzymes contained in the fish (autolysis), purified commercial preparations from various biological sources (vegetable, animal, or microbial), or the enzymes supplied by living cultures of microorganisms.

Development of a biological process was pursued because (1) the product can have special properties (e.g., solubility) which make it more suitable for certain applications than is the solvent extracted FPC, (2) it may be possible to produce an acceptable protein concentrate more cheaply

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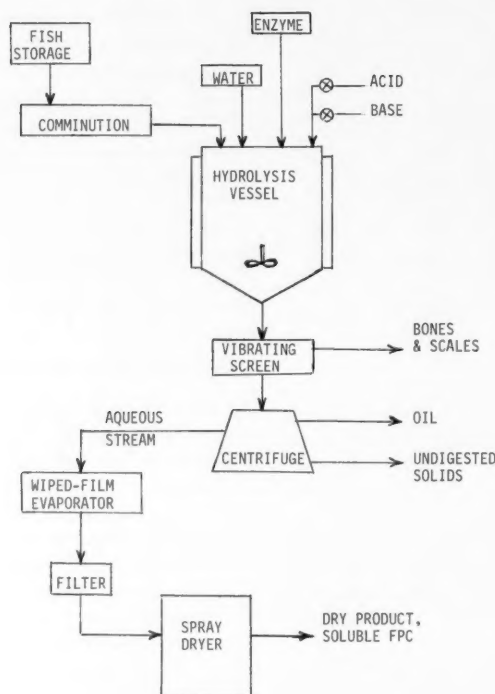


Figure 1.—Basic process outline for enzymatic hydrolysis of fish.

through biological means than through solvent extraction, and (3) a biological method with proper controls would be more suitable for use on shipboard or for use in remote areas.

A process has been developed for the preparation of a nutritious, totally water-soluble concentrate derived from fish protein which may be used to advantage in foods such as soups and beverages. Although processing costs have been considered throughout the work, the major concern has been for improvement of the amino acid pattern and nutritive value of the soluble product.

The basic biological process is depicted in Figure 1. Enzymatic digestion of a whole fish slurry with control of pH and temperature is followed by screening to remove bones and scales. Insoluble solids are separated by centrifugation and a clarified hydrolysate is spray-dried (Figure 2) to yield a soluble product consisting of peptides,

polypeptides, and some free amino acids. An alternate product, easily dispersible but only partially soluble, is prepared by eliminating the centrifugation step. Either product could be sold as a concentrated paste with elimination of the drying step.

SELECTION OF ENZYMES

In early research the relative proteolytic activities of 23 commercially available enzyme preparations were compared. A specially prepared fish protein substrate was used in standard hydrolysis tests of 1-hour and 24-hour durations. Ficin was most active for a 1-hour period. Over the longer hydrolysis period the enzymes pepsin, papain, and pancreatin ranked highest on the basis of activity per unit cost. These results were detailed in a previous publication (Hale, 1969).

When whole red hake (*Urophycis chuss*) was used the relative effectiveness of the various enzymes changed

because of the added effect of native fish enzymes. The relative effectiveness of pepsin, for instance, was low with whole fish because the native enzymes are not active at pH 2 which is optimum for pepsin. Over a period of time, many products were prepared in 5-liter batches (Figure 3) using different enzymes and processing conditions. Average yields of dry, soluble product with each type of enzyme are listed in Table 1. Amino acid analyses and

Table 1.—Average yields of dry solids from red hake solubilized by proteolytic enzymes.

Enzyme(s)	Number of runs	Yield, dry solids/wet fish, % \pm std. deviation
Autolysis	5	10.0 \pm 0.4
Pepsin	1	10.9
Papain	5	11.3 \pm 0.8
BPN	4	11.7 \pm 0.10
Bromelin, Ficin	3	12.3 \pm 0.6
Rhozyme P-11	3	12.5 \pm 0.75
Pancreatin	7	13.8 \pm 1.3
Alkaline proteases	5	14.3 \pm 1.0

limited feeding studies indicated that hydrolysis at pH 8.5 with an alkaline protease of *Bacillus subtilis* resulted in the best nutritive value as well as the highest yield of product.

HYDROLYSIS CONDITIONS AND AMINO ACIDS

Raw fish is hydrolyzed so that the activity of native enzymes is combined with that of added enzymes. In initial runs the fish was cooked as a control measure prior to hydrolysis. Both yields and nutritive value were poor. An experiment showed that the degree of solubilization achieved with raw hake could be obtained with cooked hake only if six times as much commercial enzyme were added.

Soluble hydrolysates prepared from cooked hake had low nutritive values as the sole source of protein in feeding studies with rats. The concentration of the essential amino acid tryptophan was quite low in these products. Treating raw hake under slightly alkaline conditions gave a good yield of product containing adequate tryptophan. The positive correlation between the level of tryptophan and the yield of

Figure 2.—Spray drying a partially soluble hydrolysate.

soluble solids is shown in Figure 4. The required yield of 13 percent (of fish weight) can only be obtained with added enzyme, not by autolysis alone.

Hydrolysis with pancreatin at pH 8 gave good yields of product containing adequate levels of tryptophan but the nutritive value was unsatisfactory. This corresponded with a low level of histidine, an amino acid which is essential for infants (or young rats) although not for adults. When an alkaline protease derived from the bacteria *B. subtilis* was acquired and tested at pH 8.5, both the histidine level and nutritive value of the product were significantly improved. Pancreatin also gave better results at pH 8.5 than at pH 8.

EVALUATION RUNS

Three enzymatic processes were evaluated in replicate runs using red hake. Hydrolyses with pancreatin, Alcalase¹, and by autolysis were tested by three 5-liter (1.3 gallon) batches plus a 20-gallon batch for each process. Three processes were also tested in runs with the fatty fish alewife (*Alosa pseudoharengus*) using autolysis and the alkaline protease Alcalase. Average yields and chemical compositions of raw fish and of the hydrolysates prepared from hake and alewife by each of two processes are listed in Table 2.

Protein efficiency ratios (PER's) were determined by rat feeding trials with the hydrolysates of hake and alewife and are listed in Table 3. The products prepared from hake were inferior to casein as a sole source of protein, but were statistically equivalent to casein as a supplement to wheat flour. All of the products prepared from alewife were statistically equivalent to casein as a sole source of protein. Thus, we obtained a totally soluble hydrolysate from alewife with

¹ Manufactured by NOVO Industries. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 3.—Experimental system used for fish protein hydrolysis in 5-liter batch.

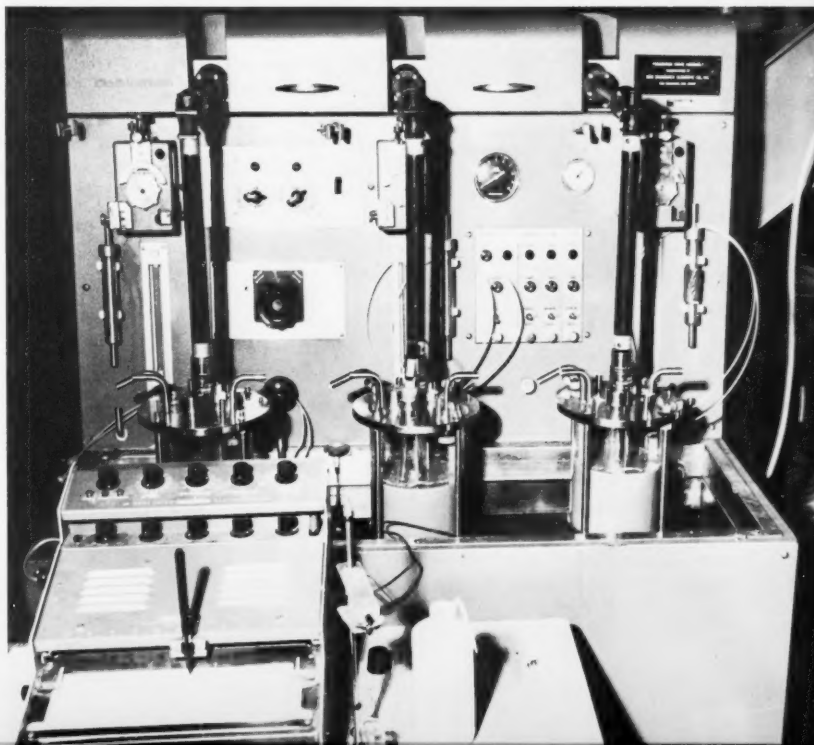


Table 2.—Yields and composition of hydrolysates and raw fish.

Item	Red hake hydrolysates		Raw hake	Alewife hydrolysates		Raw alewife
Enzyme	Pancreatin	Autolysis	—	Alcalase	Alcalase	—
Concentration	0.5%	—	—	0.5%	0.3%	—
Type of product	Soluble	Whole slurry	—	Soluble	Whole slurry ¹	—
Number of runs	4	4	8 samples	3	3	3 samples
Average yield ²	14.3%	17.9%	—	13.0%	18.7%	—
Avg. % Protein	77.23	77.85	15.89	76.01	65.24	17.16
% Moisture	4.44	4.02	79.09	4.89	4.21	71.07
% Ash	16.02	6.73	2.73	16.52	9.32	2.74
% Fat ³	0.16	12.41	3.06	0.21	25.07	8.35

¹ Prepared from alewife presscake.

² Dry product as weight percent of raw fish.

³ Total lipids by the SAK method (Smith, Ambrose and Knobl, 1964).

Table 3.—Nutritive quality of enzymatic hydrolysates of red hake and alewife.¹

Material hydrolyzed	Enzyme added	Product solubility	Protein efficiency ratio	
			Actual	% of casein
Raw hake	Pancreatin	Total	22.89 ± 0.07	82.2
Raw hake	(Autolysis)	Partial	2.87 ± 0.07	81.7
Raw alewife	Alcalase	Total	3.44 ± 0.06	97.2
Alewife presscake	Alcalase	Partial	3.40 ± 0.08	96.0

¹ Each feeding sample was a blend of the spray-dried products from three 5-liter hydrolysis batches.

² Average plus standard error of the mean.

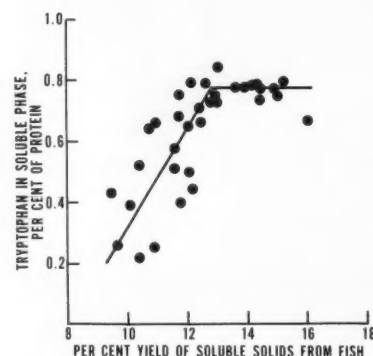


Figure 4.—Tryptophan concentration in soluble solids versus percent yield of solubles from enzymatic hydrolysis of red hake.

the desired PER level which we had been unable to reach with hake.

PRODUCT USES AND COSTS

Limited food research studies have been carried out with the enzymatic hydrolysates of whole fish. For most food applications a bland product is desirable and a good soluble protein for use in carbonated beverages would command a premium price. Flavor is probably the major unsolved problem but FPC's from whole fish could be of real value for uses in which good nutritive and supplemental value are

combined either with a special property, such as solubility, or with process simplicity and a relatively low production cost.

The most promising immediate application for biological FPC's is as a partial replacement for milk in the diets of weanling calves. The combination of good nutritive value and dispersibility make fish protein hydrolysates well suited for this use. Fish autolysates have been used as milk replacers in France. The presscake hydrolysis process also shows promise of economic feasibility.

Process flowsheets have been developed for enzymatic processes using raw whole fish and fish presscake. Material balances obtained experimentally were used to estimate pro-

duction costs for the two types of products through use of a recently developed computer program (Almenas et al., 1972). Assuming a plant processing 250 tons per day of fish costing 1.5¢/lb and operating for 200 days/year, the estimated production costs are 17¢/lb for a totally soluble FPC and 12¢/lb for the partially soluble presscake product. For a 20 percent profit after taxes on total capital investment, the estimated selling prices are 38.4¢/lb of soluble FPC and 26.7¢/lb of presscake product.

NOAA TECHNICAL REPORT

The research summarized in this paper has been described in more detail in a technical report which also includes a literature survey of biological methods for FPC production (Hale, 1972).

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MFR Paper 1034. From Marine Fisheries Review, Vol. 36, No. 2, February 1974. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.

The Mexican Marine Sport Fisheries

AURELIO SOLÓRZANO



Sport fishing is a unique recreation. It offers excitement and personal satisfaction whether conducted from the seashore; at a mountain stream; or in the open ocean, fishing for marlin or sailfish. The Mexican sport fisheries are complex and varied. Studies are needed concerning their economic, social, and cultural aspects. Because the sport fisheries serve as a tourist attraction, they stimulate economic growth; they also create better understanding and cultural appreciation among individuals and nations.

Aurelio Solórzano is a biologist with the Instituto Nacional de Pesca, Avenida Cuauhtemoc 80, Mexico 7, D. F., Mexico. The paper was translated by Maxwell B. Eldridge, Tiburon Fisheries Laboratory, National Marine Fisheries Service, NOAA, Tiburon, CA 94920. The photographs depict fishing at Rancho Buena Vista, Territory of Baja California Sur. The fish in the photograph above is a blue marlin.

The purpose of this report is to present a preliminary survey of the sport fisheries of Mexico and the factors which affect them.

GOVERNMENT AGENCIES INVOLVED WITH SPORT FISHERIES

Realizing the potential for development, the recently created Office of the Undersecretariat of Fisheries (Subsecretaría de Pesca) has established better mechanisms to promote sport fisheries. The Undersecretary has organized an Office of Sport Fisheries (Oficina de Pesca Deportiva) whose main function is to obtain sport fishing statistics from clubs, charter boats, tournaments, and all other businesses involved with sport fishing. This office operates under the Office of Fishery Regions (Dirección General de Regiones Pesqueras).

The National Institute of Fisheries (Instituto Nacional de Pesca) has ongoing biological studies which, in the

future, will provide additional information on sport fish species from all areas of Mexico. These studies will include seasonal occurrence, ecology, and life histories of sport fishes. We are also currently attempting to eliminate problems in the economics of sport fisheries. We believe that coordination of activities and ongoing biological and economic studies will provide the information necessary to accomplish this goal. Additionally, an attempt is being made to coordinate knowledge of sport fisheries to aid in economic planning of the industry. To further aid the industry the Mexican government has enacted legislation (Article 10 of the New Law for the Development of Fisheries) which protects certain species of fishes. It states:

"A fishery is considered a sport fishery when without purpose of gaining financial profit, it is conducted for the purpose of recreation and practiced with appropriate sport fishing equipment. Fish species



Figure 1.—There is excellent sport fishing on both coasts of Mexico. The waters of the northwest, particularly around Baja California, account for most sport fishing permits.

reserved exclusively for sport fishing are marlin, sailfish, tarpon, roosterfish, dolphin, and any other species designated by the National Institute of Fisheries."

BILLFISH RESOURCES AND AREAS OF FISHING

The eastern and western shores of Mexico are famous for the many sport fishing areas which have facilities providing sport fishing for the many fish species.

THE SPORT FISHES

Sailfish (pez vela, *Istiophorus platyterus*): Sailfish have been reported in the Pacific from Monterey, California to Cape Blanco, Peru. In Mexico it is fished at La Paz (Baja California), Mazatlán (Sinaloa), and Acapulco (Guerrero) (Figure 1). In Mexico sailfish are commonly found off southern Baja California, in the Gulf of California, and southward to the Guatemalan border. Near Baja California, they most frequently occur in the areas off Buena Vista, Punta Colorado, San José del Cabo, and Punta de Lobos. Some sport fishermen have indicated

that sailfish are seasonally abundant off the coast of the state of Colima with Manzanillo as the center of abundance. In the area off Acapulco sailfish are caught throughout the year. The highest catches occur during the winter months. Off Mazatlán and farther north into the Gulf of California they occur in largest numbers from May to October.

Sailfish are also reported from the Caribbean and throughout the Gulf of Mexico, ranging from Brazil to Massachusetts. Occasionally they are caught off the state of Veracruz, especially near Tuxpan.

Striped marlin (marlin rayado, or agujón, *Tetrapterus audax*): Fishing for striped marlin is occasionally good off Acapulco, Zihuatanejo, and Cabo San Lucas. Fishing is especially good at Cabo San Lucas. There striped marlin are reported seasonally abundant from December to June although there are few recorded data. Striped marlin are also fished in waters off Guaymas (Sonora), Mazatlán, and Puerto Vallarta (Jalisco).

Black marlin (marlin negro, *Makaira indica*): Black marlin have been reported in southern Baja California, Guaymas, La Paz, Mazatlán, Puerto

Vallarta, and less frequently off Zihuatanejo and Acapulco. Little is known of catches by sport fishermen south of Acapulco and even less from the Gulf of Tehuantepec, for there is essentially no sport fishing in these southern areas.

Swordfish (Pez espada, *Xiphias gladius*): Swordfish arouses as much interest among sport fishermen as sailfish and marlin. They range extensively throughout temperate and subtropical waters and are fished in waters along the west coast of Mexico from the Gulf of California southward. Off Acapulco swordfish do not appear to be abundant. Unfortunately, the swordfish catch data are not reliable. Japanese commercial longline catch data indicate seasonal abundance of swordfish off central and southern Baja California during October-February.

OTHER SPORT FISH RESOURCES

Other sport species which are reported to be abundant in Mexican waters are the following: tarpon (sabalo, *Tarpon atlanticus*); tuna (atun, *Thunnus* spp.); skipjack tuna (barrilete, *Katsuwonus pelamis*); bonito (*Sarda* sp.); mackerels (makeral, *Scomber japonicus*, *S. scomber*); barracuda (*Sphyraena* sp.); wahoo (peto, *Acanthocybium solandri*); Bonefish (macabi, *Albula vulpes*); dolphin (dorado, *Coryphaena hippurus*); roosterfish (pez gallo, *Nematistius pectoralis*); totuava (totoaba, *Cynoscion macdonaldi*); jacks (jureles, *Caranx* spp.); snappers (pargos, huachinangos, *Lutjanus* spp.); snook (robalos, *Centropomus* sp.); yellowtail (jurel, *Seriola dorsalis*); and black sea bass (mero, *Epinephelus* sp.).

Also reported as numerous are various species of sharks, of which the following would certainly be formidable game species: tiger shark (tiburón tigre, *Galeocerdo cuvieri*); great white shark (*Carcharodon carcharias*); great hammerhead shark (pez martillo, *Sphyrna mokarran*); shortfin mako

shark (tiburón paloma, *Isurus oxyrinchus*). Some of these sharks attain lengths of 15 to 20 feet.

THE SPORT FISHERIES

The marine sport fisheries can be classified in two categories:

- (1) the commercial sport fishery, using charter or "party" boats; and
- (2) fishing from private boats and from shore.

Within these categories 200,623 sport fishing permits were issued during 1971, of which 111,597 (56 percent) were issued in San Diego and San Pedro, Calif., mostly to party-boat fishermen. The areas fished by these partyboats are: Coronado Islands, Cedros and Benitos Islands, Guadalupe Island, Socorro Island, and localities near Ensenada and Cabo San Lucas. Most trips last from one to eight days. The species most sought



Right, landing a roosterfish; below, a view of part of the sport fishing charter fleet.



after are: marlin, bonito, skipjack, barracuda, albacore, yellowfin tuna, yellowtail, and black sea bass.

Of the total of 89,026 permits issued within the Republic of Mexico in 1971, about 62 percent were from the states of Baja California and Sonora, and the Territory of Baja California Sur. Most sport fishing permits were issued from offices in Ensenada, La Paz, and Guaymas. Thus, it can be seen that the waters of northwestern Mexico are the most popular to both Mexican and foreign sport fishermen.

Acapulco accounted for a total of 21,426 permits (24 percent) followed by Mazatlán with 3,304 (3.7 percent) and Puerto Vallarta with 707 (0.7 percent).

SPORT FISHING TOURNAMENTS

Throughout the year different sport fishing tournaments are held on both coasts. Some are internationally famous, such as those for tarpon at Tampico and Tuxpan, and for billfish at Guaymas, Mazatlán, Cabo San Lucas, and Acapulco. Some of these tournaments are organized through sport fishing clubs, and others by private individuals who promote such

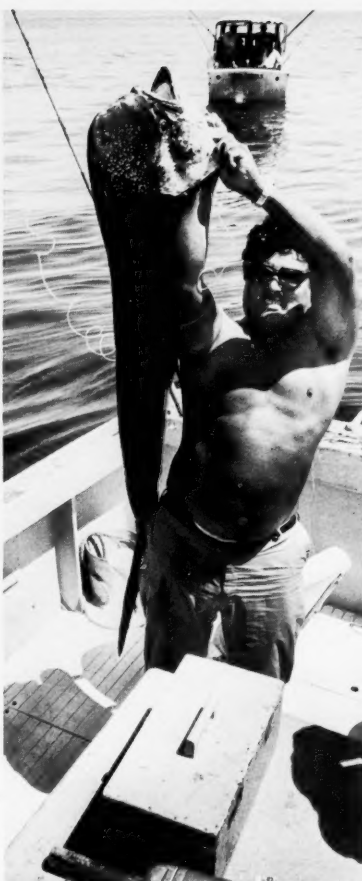
The dolphin, or mahimahi, is caught off Mexico (right).

events for business purposes. Up to now there has not been a true coordination of these tournaments, nor have their results ever been evaluated, either in terms of promotional success or as sporting events.

THE FUTURE OF SPORT FISHERIES IN MEXICO

The growing sport fisheries will provide employment opportunities to help meet the needs of Mexico's expanding population. Proper planning, promotion, and regulation will maximize these opportunities. The newly enacted law recognizes the importance of sport fisheries, and by reserving certain species, will aid in the development of the industry.

Development of the sport fisheries is hampered by the lack of published information on distribution and abundance of species of fishes, and on the availability of facilities. Attempts are being made to consolidate such information and disseminate it through travel agencies and other avenues of contact with the sport fishing lovers of the world.



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A new net and a new
technique improve sampling
of small fishes.

Variable-Mesh Beach Seine for Sampling Juvenile Salmon in Columbia River Estuary

CARL W. SIMS and RICHARD H. JOHNSEN

ABSTRACT

A 332-foot variable-mesh beach seine has been developed to sample juvenile salmon, *Oncorhynchus* spp., in the Columbia River estuary. This net is designed for a two- or three-man operation and can be set with a small boat (18-20 feet) powered by an outboard engine (40 hp minimum). The net is particularly effective at capturing juvenile fall chinook salmon, *O. tshawytscha*, coho salmon, *O. kisutch*, chum salmon, *O. keta*, and cutthroat trout, *Salmo clarki*; it can also be used to sample various other species in the estuarine environment.

INTRODUCTION

Effective fishing gear is of primary importance to research and management workers concerned with sampling juvenile salmon, *Oncorhynchus* spp., in the estuarine environment. The National Marine Fisheries Service Biological Field Station at Hammond, Oreg., has developed a variable-mesh beach seine and seining technique that have proven particularly effective for sampling juvenile chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *O. kisutch*, chum salmon, *O. keta*,

and cutthroat trout, *Salmo clarki*, in the Columbia River estuary. This paper describes this net and the technique used for its operation.

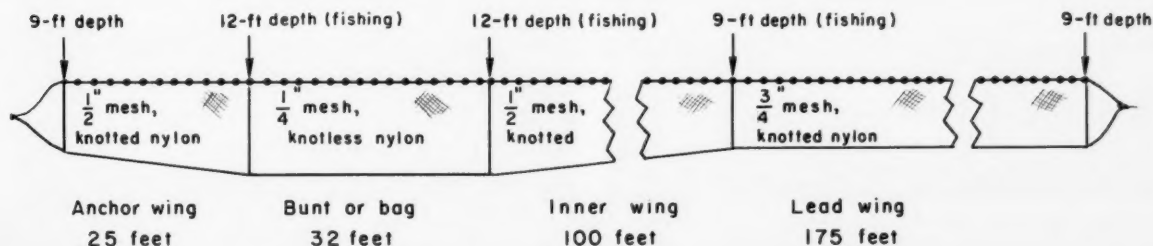
THE NET

The net is a variable mesh, single lead beach seine. Length and mesh size are dependent upon the purpose for which the net is to be used. The net we have used most effectively for sampling juvenile salmon and trout in the Columbia River estuary is 332 feet long on the cork line, fishes to a depth

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of 12 feet at the bunt (600 meshes deep $\frac{1}{4}$ inch mesh), and is cut to taper from 12 feet (300 meshes deep $\frac{1}{2}$ inch mesh) to a fishing depth of 9 feet (230 meshes deep $\frac{1}{2}$ inch mesh and 200 meshes deep $\frac{3}{4}$ inch mesh) at the wing (Figure 1). The net consists of three sections: lead wing, bunt, and anchor wing. The lead wing is further divided into two sections: a 175-foot outer or lead section of 210 d/18 \times $\frac{3}{4}$ inch stretched mesh (No. 6 nylon, 3.725 ft/lb) knotted nylon seine netting and a 100-foot inner section of 210d/15 \times $\frac{1}{2}$ inch stretched mesh (No. 5 nylon, 4.650 ft/lb) knotted nylon. Both

Figure 1.—A variable-mesh beach seine designed for sampling juvenile salmon in the Columbia River estuary. Depth values designate "fishing depth."





a



d



b



e



c



f

Figure 2.—Fishing the variable-mesh beach seine in the Columbia River estuary. (a)—picking up the net. (b)—upstream tow. (c)—downstream sweep. (d)—closing the net. (e)—hauling the net. (f)—bagging the catch.

sections are hung at 1½ feet of webbing to 1 foot of float and lead line (33 percent hang-in). Section stringers are of ¾ inch polypropylene.

The 32-foot bunt or bag section is made of ¼ inch knotless nylon web hung at 3 feet of web to 1 foot of float and lead line (66.6 percent hang-in). The 25-foot anchor wing is made of 210 d/15 × ½ inch stretched mesh knotted nylon (No. 5 nylon, 4,650 ft/lb) and is hung the same as the lead wing.

The cork-line is 7/16 inch polypropylene with webbing hung at 5-inch intervals. Floats used are B. F. Goodrich sponges k-4 grommets plastic (14 ounce average buoyancy each) and are spaced at 24-inch centers.¹ The lead line is 120-pound/100-fathom size lead core. The gavels or breast lines are ¾ inch polypropylene and are 9 feet long. A 100-foot tow line of 7/16 inch polypropylene is attached to a 10-foot bridle made of the same material.

FISHING TECHNIQUE

The seine is best suited for beaches of sand, hard mud, or small gravel. It can be fished effectively by a two-man crew using an 18- to 20-foot boat powered by an outboard motor (40 hp minimum power). During periods of sustained operation or when large numbers of fish are being taken, the addition of a third crewman is advisable.

To set the net, the anchor wing is attached to an anchor or log on the beach and the net is laid out along the water's edge in the direction of the current. The tow line is picked up by the boat and the net is towed into the current as close to the beach as possible without grounding the motor (Figures 2a and 2b). At the end of the

Table 1.—Beach seine catches at brackish water sampling stations in the Columbia River estuary, 1970.

Species	Month and (in parentheses) no. of sets					Total catch
	April (46)	May (28)	June (33)	July (67)	August (80)	
<i>Alosa sapidissima</i> ¹	2	2	6	3	2	15
<i>Ammodytes hexapterus</i>	0	126	3	0	0	129
<i>Catostomus macrocheilus</i>	0	33	104	9	5	151
<i>Clupea harengus pallasii</i>	0	1,859	374	245	196	2,774
<i>Cymatogaster aggregata</i>	5	0	5,237	3,822	14,683	23,747
<i>Cyprinus carpio</i>	0	142	26	54	13	235
<i>Engraulis mordax</i>	0	0	13	1	2,042	2,056
<i>Gasterosteus aculeatus</i>	13	99	171	594	643	1,520
<i>Hypomesus pretiosus</i> ²	728	4,342	19,900	9,049	4,073	38,092
<i>Leptocottus armatus</i>	1	37	139	376	450	1,003
<i>Merluccius productus</i>	0	0	12	1	7	19
<i>Microgadus proximus</i>	0	0	0	0	21	21
<i>Mylocheilus caurinus</i>	127	0	10	161	218	516
<i>Oncorhynchus keta</i> ¹	589	206	0	0	0	795
<i>O. kisutch</i> ¹	217	399	12	4	0	632
<i>O. nerka</i> ¹	0	0	0	2	0	2
<i>O. tshawytscha</i> ¹						
Less than 1 year old	79	2,700	3,220	8,516	1,055	15,570
Yearlings	111	1	0	0	0	112
<i>Platichthys stellatus</i>	54	67	229	787	654	1,789
<i>Psettichthys melanostictus</i>	1	2	27	0	1	31
<i>Salmo gairdneri</i> ¹	4	6	0	0	1	11
<i>Syngnathus griseolineatus</i>	0	2	1	0	0	3

¹ Juveniles only.

² Totals for this species include an unknown number of *Spirinchus dialatus*.

Table 2.—Beach seine catches at a freshwater sampling station in the Columbia River estuary, 1970.

Species	Month and (in parentheses) no. of sets					Total catch
	April (390)	May (545)	June (700)	July (607)	August (178)	
<i>Acipenser transmontanus</i> ¹	0	0	5	23	1	29
<i>Alosa sapidissima</i> ¹	99	1,788	11,199	1,674	739	15,499
<i>Catostomus macrocheilus</i>	9	24	59	27	3	122
<i>Cottus asper</i>	0	24	235	50	40	349
<i>Cyprinus carpio</i>	18	126	44	72	1	261
<i>Gasterosteus aculeatus</i>	21,402	23,521	12,220	45,029	27,180	129,352
<i>Ictalurus nebulosus</i>	0	3	1	0	0	4
<i>Lepomis macrochirus</i>	0	12	4	2	1	19
<i>Micropterus salmoides</i>	15	9	5	13	12	54
<i>Mylocheilus caurinus</i>	67	1,078	2,503	1,162	439	5,249
<i>Oncorhynchus keta</i> ¹	32	137	4	0	0	173
<i>O. kisutch</i> ¹	9,826	34,711	502	29	2	45,070
<i>O. nerka</i> ¹	33	21	19	8	0	81
<i>O. tshawytscha</i> ¹						
Less than 1 year old	3,506	67,783	44,701	83,334	29,156	228,480
Yearlings	3,868	3,194	361	838	980	9,241
<i>Perca flavescens</i>	16	441	973	667	71	2,168
<i>Platichthys stellatus</i>	218	408	569	474	136	1,805
<i>Pomoxis nigromaculatus</i>	6	77	102	13	5	203
<i>Prosopium williamsoni</i> ¹	5	1	29	136	62	233
<i>Ptychocheilus oregonensis</i>	0	2	0	1	2	5
<i>Salmo clarki</i>	301	360	37	7	62	767
<i>S. gairdneri</i> ¹	178	750	67	3	10	1,008
<i>Thaleichthys pacificus</i>	13	0	0	0	0	13

¹ Juveniles only.

tow, the net is swung back with the current (Figure 2c). During the sweep, just enough power is used to keep an arc in the net. Excessive pull tends to lift the leadline and results in lowered efficiency. At the end of the sweep, the lead wing is closed (Figures 2d and 2e) and the net is worked along the beach, one man to the floatline and one to the leadline, until the catch is forced into the bag (Figure 2f). After

the catch is removed from the bag, the net is in position to be reset without further handling.

SEINE CAPABILITIES

This beach seine has proven to be an effective tool for sampling fall chinook salmon less than 1 year old, yearling coho salmon, chum salmon fry,

¹ Reference to trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service, NOAA.

and cutthroat trout fry. It has not been particularly effective at sampling yearling chinook salmon, yearling sockeye salmon, *O. nerka*, or yearling steelhead trout, *S. gairdneri*. These species are generally found in the deeper channel areas and are much more susceptible to purse seining than to beach seining (Johnsen and Sims, 1973).

Catches of more than 1,000 fall chinook and 500 coho salmon per set have not been uncommon at the better sampling sites. Generally, our catches range from about 50 to 500 fall chinook per set and from 50 to 300 coho

per set during the peak of the outmigrations.

Although this net was specifically designed to sample juvenile salmon, its usefulness is not restricted to these species. Tables 1 and 2 show the catches from freshwater and brackish water sampling stations in the Columbia River estuary. These sampling sites were chosen for their abundance of juvenile salmon. Catches of any other particular species could be greatly increased by fishing in areas more favorable to their abundance. We feel that this seine would be especially adapt-

able to sampling juvenile American shad, *Alosa sapidissima*, Pacific herring, *Clupea harengus pallasii*, northern anchovy, *Engraulis mordax*, starry flounder, *Platichthys stellatus*, and many of the smelts.

A significant advantage of this seine as a sampling tool is that the captured fish are generally in good condition and can be released with minimal mortality.

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Scientists study menhaden fish solubles and fish oils as nutrient supplements in mushroom culture.

Mushroom Culture: A New Potential for Fishery Products

JOHN H. GREEN

ABSTRACT

*This paper describes research sponsored by the National Marine Fisheries Service, NOAA, and being done at the Mushroom Research Center, Pennsylvania State University, to explore menhaden (*Brevoortia tyrannus*) fish solubles and fish oils as nutrient supplements in mushroom culture. Fish solubles were successfully substituted for other organic nitrogen supplements commonly used in mushroom composting and subsequent mushroom culture. These experiments, performed in 1971-1972, indicated that in certain situations larger mushrooms were produced when combinations of fish solubles and other organic nitrogen supplements were used. Currently under investigation in 1973-1974 is the use of fish oils, substituted for polyunsaturated vegetable oils, to stimulate increased yields of mushrooms. A brief description of mushroom cultivation is given with emphasis on nitrogen supplementation of composts and polyunsaturated oil stimulation for increased mushroom yields.*

These investigations of menhaden fish solubles and fish oil could open up new markets for these products. At the same time, they could offer the mushroom grower new and inexpensive sources of nitrogen supplements or nutrient stimulants. Both industries could benefit from these applications of fishery products or by-products. An economic prospectus is given of this potential market with estimations of the maximum volumes.

INTRODUCTION

Mushrooms (basidiomycetes) are fungi which man has used for food over countless centuries. Through interests in single cell protein production, we became aware of the possibility that fishery products and by-products might be utilized in mushroom culture. The centers of mushroom culture in the United States are located primarily in the northern Mid-Atlantic

States, mainly in southeastern Pennsylvania. There is a smaller but expanding industry concentrated in the West Coast States and the Great Lakes Region, mainly in Michigan and Ohio. Several other states, including the coastal states of Massachusetts, Virginia, Georgia, and Florida, produce mushrooms on a scale smaller than the above-mentioned areas. The mushroom industry in the United States is growing.



Figure 1.—Mushrooms growing on compost. (Photograph, courtesy of Pennsylvania State University.)

The College Park Fishery Products Technology Laboratory became interested in exploring the feasibility of using fishery products and by-products in mushroom culture. Helpful information and guidance on the requirements of mushroom culture were initially received from Drs. James P. San Antonio and Claude Fordyce, Jr., of the U.S. Department of Agriculture Mushroom Research Group, Beltsville, Md. (Dr. Fordyce is now with the L. F. Lambert Spawn Company, Coatesville, Pa.). A contract was made later with Dr. Lee C. Schisler of the Mushroom Research Center at the Pennsylvania State University, and his expertise was put to work to explore the feasibility of using fish solubles as an organic nitrogen supplement in making compost for mushroom culture and fish oil as a stimulant for increased mushroom yield. The initial results of these experiments look promising and although further experimentation will have to be done, there are promises of new potential

John H. Green is a member of the staff of the College Park Fishery Products Technology Laboratory, National Marine Fisheries Service, NOAA, College Park, MD 20740.



Figure 2.—Large pile of compost being formed. (Photograph, courtesy of Butler County Mushroom Farms, Inc.)

uses for fish oils, fish solubles, and perhaps other fishery byproducts or condensed waste effluents as nutrient supplements in mushroom culture (Green et al., 1973; Schisler and Patton, 1973).

COMPOSTING AND NITROGEN SUPPLEMENTS

Mushrooms are grown commercially on the traditional horse manure compost. In more recent decades a "synthetic" mushroom compost has been developed consisting of corn cobs and hay. Horse manure compost is still being used by the majority of the mushroom growers and "synthetic"

compost is used by about 40 percent of this industry. There is now a growing interest by many concerns to grow mushrooms on composted waste such as city garbage, agricultural waste, and residue from various industrial processes. Disposal of waste by composting followed by mushroom culture could help solve some of the solid waste disposal problems. Although the technique is largely experimental now, the future may see more of this in actual production. No matter which type of compost is used, the ingredients of gypsum for texture and one or more types of organic nitrogen sources are mixed in at the initiation of composting.

In order to assure the good composting which is necessary for good mushroom production, the grower must raise the initial nitrogen content of the compost from approximately 0.8-1.2 percent to 1.5-1.7 percent on a dry weight basis. To do this, he adds one or more organic nitrogen sources, such as dried chicken manure (2-6 percent N), dried brewers grains (4 percent N), cottonseed meal (7.0 percent N), cocoa bean hulls (3 percent N), and other materials containing organic nitrogen. Chicken manure varies in its nitrogen content and presents problems to the mushroom grower in terms of consistency, proper mixing, and occasional excess ammonia formation during composting. Excess ammonia inhibits mushroom growth. Inorganic nitrogen or small organic molecules, such as urea, are usually less expensive but they

often leach out of the compost pile during watering operations. In addition, inorganic nitrogen does not give results as good as those of organic nitrogen, hence the desire for organic nitrogen substances by the mushroom grower. Their supplies of desired nitrogen supplements are becoming more expensive as the demand for these materials increases for this and other uses. There are companies that supply mushroom growers with a mixture of dried, fortified organic nitrogen substances of guaranteed nitrogen consistency. We became interested in the possibility that fish solubles, which is quite consistent in nitrogen, 5 percent, might be used for this purpose. A contract was made with Dr. Schisler to explore the use of menhaden fish solubles as a nitrogen

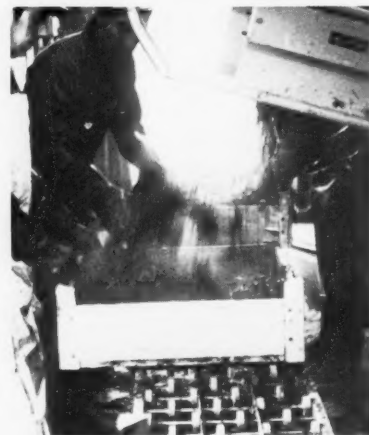


Figure 4.—Filling trays with experimental compost containing polyunsaturated oils at Pennsylvania State University.

supplement in mushroom composting.

The nitrogen supplement does not directly supply nutrients to the mushroom. Nitrogen and other supplements are important in supporting the microbial growth of the compost process which must go on prior to planting with mushroom spawn. The composting is carried on by a variety of microorganisms, including thermophilic bacteria, actinomycetes, and fungi. To further encourage this compost

Figure 3.—Experimental pile of compost, containing fishery byproducts, at Pennsylvania State University.





Figure 5.—Typical mushroom growing houses on a Pennsylvania farm. (Photograph, courtesy of U.S. Department of Agriculture.)



Figure 6.—Professional supervision and maintenance of mushroom spawn cultures which are used to inoculate new beds or trays of compost. (Photograph, courtesy of Butler County Mushroom Farms, Inc.)

microbial growth, the huge piles of compost ingredients are periodically watered and aerated by turning to achieve good aerobic growth. Temperatures of the compost reach as high as 165-175° F. When the peaks of rapid

microbial growth and temperature are reached, which ends Phase I of composting, the hot, raw compost is placed in beds or trays inside mushroom houses which are then steamed to continue Phase II of composting at a lower temperature (120-135° F) to finally condition compost. The heat generated during Phase II and supplemental steam are utilized to pasteurize the mushroom house by killing off insects, nematodes, and competing fungi.

The entire composting operation takes from 2 to 3 weeks. Good aerobic growth of these composting microorganisms yields a biologically stable compost of mushrooms, which are really slow growing fungi. Poor composting produces poor or no yields of mushrooms. Therefore, the compost ingredients and procedures are very important in order to get good yields of mushrooms.

When composting is completed, the trays or beds of compost are

planted with a pure culture of mushroom spawn. The newly spawned compost is allowed to develop mycelium growth and then it is covered with a thin layer, usually topsoil or peat called casing. This casing layer is necessary in order for the mycelium growth to produce fruiting bodies (mushrooms). Sometimes nutrients are added to the mushroom cultures at the time of casing. This is referred to in the trade as SACING (Supplementation At Casing). In the future, some of the fishery products and by-products might find uses in SACING. Experimentation would be needed to show this application.

In the United States the only mushroom species grown of commercial importance is *Agaricus bisporus*; however, there are many different strains which are grown for various purposes. In the Eastern and Midwestern States, fresh mushrooms sold in markets are usually white strains. The faster and more abundant growing cream or brown strains are grown for canning because either white, cream, or brown essentially are the same color in the final canned product. In the West Coast States, only the cream

Figure 7.—Mushroom spawn (mycelium grown on sterilized, sprouted cereal grains) being spread on compost. (Photograph, courtesy of U.S. Department of Agriculture.)



or brown strains are grown and used for either the fresh market trade or canned products.

Some general references to mushroom culture are the following: Lam-

bert (1967), Butler County Mushroom Farms Inc. (1969), Snetsinger (1970), and Kinrus (1971). Fish solubles have been described by Soares et al. (1970, 1973).

THE EXPERIMENT

Dr. Schisler and his assistant Mr. Thomas Patton conducted an experiment using Atlantic menhaden fish solubles as a nitrogen supplement in compost. The fish solubles were substituted for either one or the other or both of the two organic nitrogen supplements routinely used on a 50:50 nitrogen basis at the University's experimental mushroom research facility. These two nitrogen supplements were: brewers grains which is known to be among the best of nitrogen supplements, but is becoming expensive for the grower; and a commercially available fortified nitrogen supplement called Acto 88¹ (Mushroom Supply Company, Toughkenamon, Pennsylvania) which has a guaranteed nitrogen content of 8.8 percent and is used by many growers in the Eastern States. Four experimental composts, including one control, were placed into 2-ft × 2-ft trays and spawned with two strains of mushrooms—a white and a cream strain. Throughout the harvest period, the experimental trays were picked daily and the weight and number of mushrooms for each tray were recorded. At the end of harvest the total yields and the average weights as determined by yields divided by



Figure 10.—Experimental trays of mushrooms being checked for yields. (Photograph, courtesy of Butler County Mushroom Farms, Inc.)

number of mushrooms were made for each experimental condition and subjected to statistical comparison.

The results of Dr. Schisler's experiment with fish solubles are shown in Tables 1 and 2. It is observed in Table 1 that in most situations when fish solubles replace brewers grains (Composts Nos. 2 and 4), the yields are significantly less. However, fish solubles can replace Acto 88 (Compost No. 3) and give equal results. An interesting observation is made in Table 2 that when fish solubles are in combination with brewers grains (Compost No. 3), the mushrooms were significantly



Figure 8.—Thin layer of casing (top soil or peat) being placed over tray of spawned compost to enhance the production of fruiting bodies (mushrooms). (Photograph, courtesy of Butler County Mushroom Farms, Inc.)

Figure 9.—Stacked trays of growing mushrooms inside mushroom house. (Photograph, courtesy of U.S. Department of Agriculture.)



¹ Reference to trade name does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 11.—Picking mushrooms, trimming butts (waste), and sorting into baskets. (Photograph, courtesy of Butler County Mushroom Farms, Inc.)



Figure 12.—Mushrooms cultured on compost (upper right), freshly picked and trimmed (center) and trim waste (lower left). (Photograph, courtesy of Pennsylvania State University.)

larger; also in the white strain (Compost No. 2) even though the total yield was less in the latter. Dr. Schisler and Mr. Patton are preparing a report of these results.

Larger sized mushrooms would be of economic importance to the mushroom grower. The larger sized mushroom would bring a better price in the market and they would also represent less picking time for the same harvest yield. Hand picking is one of the remaining costly operations for mushroom growers. Many other operations involved in mushroom growing have been mechanized, but

Table 1.—Relative yields of mushrooms grown on horse manure-straw-gypsum mixture compost containing fish solubles as nitrogen supplement and compared to control.

Nitrogen supplement ¹	White strain ²	Cream strain ³
1. Brewers grain Acto 88	Control	Control
2. Fish solubles Acto 88	Less ⁴	Less ⁴
3. Brewers grain Fish solubles	Equal	Equal
4. Fish solubles	Equal	Less ⁴

¹ Nitrogen supplements were added so that each supplement contributed 50 percent of the N. The total N in all composts is the same.

² White strains are used for fresh market mushrooms in the Eastern states.

³ Cream strains usually grow faster, yields are greater, and they are used for commercial canning.

⁴ Very significant differences ($P < 0.01$).

Table 2.—Relative size of mushrooms grown on horse manure-straw-gypsum mixture compost containing fish solubles as nitrogen supplement and compared to control.

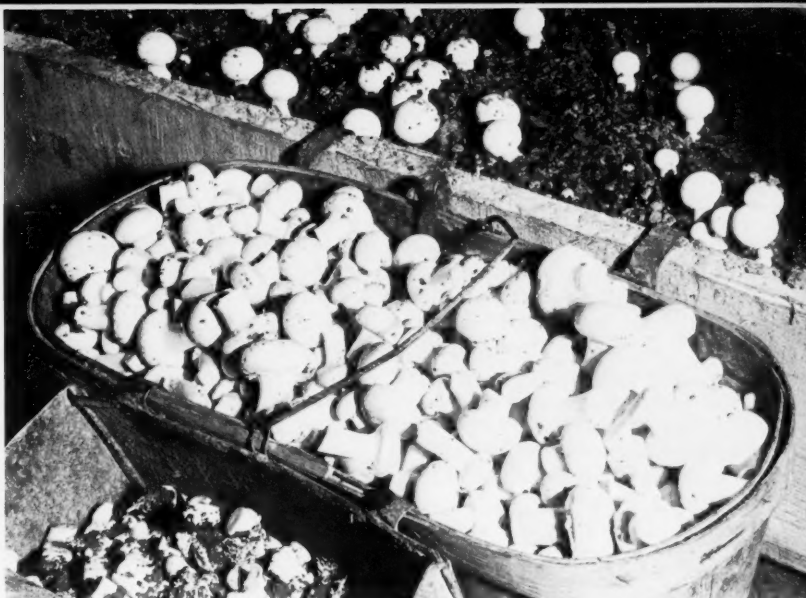
Nitrogen supplement ¹	White strain ²	Cream strain ³
1. Brewers grain Acto 88	Control	Control
2. Fish solubles Acto 88	Larger ⁴	Equal
3. Brewers grain Fish solubles	Larger ⁴	Larger ⁴
4. Fish solubles	Equal	Equal

¹ Nitrogen supplements were added so that each supplement contributed 50 percent of the N. The total N in all composts is the same.

² White strains are used for fresh market mushrooms in the Eastern states.

³ Cream strains usually grow faster, yields are greater, and they are used for commercial canning.

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the present system found on many mushroom farms of fixed mushroom beds stacked inside houses can only be picked by hand. Hence, there is interest in nutrients which will stimulate larger sized mushrooms.

IN TERMS OF FISH SOLUBLES, OTHER BYPRODUCTS

The amount of nitrogen supplement used per ton of compost would vary depending upon the initial concentrations of nitrogen in the horse manure, corn cobs, hay, etc. A range of about 6.7-13.2 pounds (dry weight) of nitrogen per ton is required to formulate the desired mushroom compost. This would be the equivalent of

135 to 270 pounds of fish solubles at 5 percent N. An estimated 1,200,000 tons of compost were produced in 1973, based on USDA Mushroom Report (1973) citing about 102 million square feet of mushroom production area for that year (each 1,000 sq ft of mushroom growing area would require about 11-12 tons of compost). This would have required the equivalent of about 80,000 to 160,000 tons of fish solubles for 1973. Assuming the maximum of 160,000 tons at a price of \$50/ton (general market price prior to 1973), this would represent a \$8 million market. Bearing in mind that certain nitrogen supplements, like brewers grains, are desired or

Figure 13.—Fresh mushrooms ready for slicing and putting into tasty food dishes. (Courtesy, Butler County Mushroom Farms, Inc.)



others, like chicken manure or cocoa husks, are readily available in certain areas, also that the amount of nitrogen used depends upon the initial nitrogen content of the horse manure, etc; this maximum potential for fish solubles could never be realized. However, even 25-50 percent of this estimate would represent a good new market for fish solubles.

More investigations should be done in the use of fish solubles in mushroom composting to achieve the following: to confirm the present results; to explore seasonal or regional variations; to try fish solubles as supplements to "synthetic" compost; and to explore different handling techniques. There is also need to explore other nitrogenous fishery byproducts or condensed waste effluents as nutrient supplements to mushroom culture. An important consideration for this potential fishery byproduct utilization is that byproducts with high fish oil residues would probably be advantageous for mushroom culture.

POTENTIAL FOR FISH OILS

A few years ago, Dr. Schisler began experiments with vegetable oils as nutrients to mushroom growth. He discovered that polyunsaturated vegetable oils, such as cottonseed and soybean added before Phase II of composting stimulated increased yields of mushrooms by 15-20 percent (Schisler and Patton, 1970). After Dr. Schisler's investigations of about 3 years ago, mushroom growers began using vegetable oils. Now about 12 percent of the mushrooms grown are produced on composts supplemented with vegetable oils to increase their yields. It is expected that nearly all of the growers will eventually be using oils for this purpose. Since fish oils are more polyunsaturated than most vegetable oils, experiments were begun to explore menhaden fish oil as a possible stimulant to increase mushroom yields.

The estimation for the consumption of polyunsaturated oils as stimulants for increased mushroom production

would be a maximum of 11,700 tons of oil (2.8 million gallons) per year based on 1973 mushroom production figures (USDA 1973). This is based on the recommendation of 110 gallons of oil per 4,000 sq ft of mushroom growing area, or approximately 45 tons of compost, which is the capacity of the common small growing unit ("single" mushroom house). At a market price of 12 cents per pound (an approximate 1972 price), a potential domestic market for fish oils of \$2.8 million could be realized. Currently mushroom growers using oils in compost are purchasing crude cottonseed or soybean oil at about 30-32 cents per pound (summer, 1973). Mushroom production capacity has been increasing in the United States on the average of 6-8 percent in the past few years; therefore, it is a growing market. There is also a potential foreign market in Europe and Asia where large amounts of mushrooms are grown. Thus, the use of fish oils in mushroom culture could represent an economic advantage to the fisheries and to the mushroom grower as a supply of inexpensive polyunsaturated oil that would increase his mushroom yield.

CONCLUSION

Both fish solubles and fish oils could represent economic advantages to both the fisheries as new markets and to the mushroom growers as inexpensive nutrient supplements that would increase their yields and that might increase mushroom size. Other

fishery byproducts and solid/sludge wastes might also serve as nutrient supplements in mushroom culture. Such utilization would help in pollution abatement by finding outlets for fishery byproducts. It would also make new sources of nitrogen supplements available to the mushroom grower in his continual search for materials available and suitable for mushroom composting.

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*Inexpensive plastic containers
stacked nine high keep fish
in good condition aboard ship.*

Effect of Draining Method on the Quality of Fish Stored in Boxes

JOHN A. PETERS, ALLAN F. BEZANSON, and JOHN H. GREEN

ABSTRACT

To determine if specially constructed fish boxes which drain the meltwater to the outside of the box are required to protect the fish in the lower layers from contamination by drainage from the upper layers are necessary for successful boxing at sea, trials were conducted in the Center using readily available plastic tote boxes.

Results of taste panel and microbiological tests on haddock stored with ice in these boxes showed no significant difference in quality between fish from the upper and from the lower boxes.

Therefore, fish can be boxed at sea using inexpensive containers rather than expensive, specially constructed fish boxes.

INTRODUCTION

It has long been known that bulk stowage of fish in pens hastens quality loss through crushing and bruising of the fish. Also, bulk stowage causes weight losses of up to 7 percent in cod and up to 15 percent in haddock at the bottom of a 3-foot deep pen (Burgess, et al., 1965).

Boxing of fish has been a fairly common practice on inshore vessels in many countries (Anonymous, 1970, p. 13), but until recently it has not been practiced on vessels fishing the more distant grounds. However, since 1965 when successful trials were conducted by the White Fish Authority aboard the Aberdeen, Scotland, vessel, *M. T. Summervale*, and in subsequent trials aboard other vessels in which it was found that boxing fish extended the storage life by 1½ to 3 days, resulted in a weight gain of about 5

percent as opposed to the losses cited above, and an increased fillet yield of about 5 percent (Anonymous, 1965, 1967a, 1967b), the adoption of boxing at sea has spread and is now becoming almost common practice in the United Kingdom.

In the United States, however, boxing at sea has not been adopted on the larger vessels. One of the reasons given is the cost of the special boxes specified by the Torry Research Station and the White Fish Authority, where an important requirement is that when the boxes are stacked, the water from the melting ice drains to the outside and does not pass through the lower layers of boxes and thus contaminate the lower fish with bacteria-laden slime (Anonymous, 1965 and Hopper, 1970).

But if the meltwater does not in fact hasten spoilage of the lower layers of fish, it would then be possible to

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use inexpensive, readily available, plastic nest and stack tote-boxes or non-returnable wooden wire-bound boxes such as are commonly used in shipping poultry, produce, etc. To settle this point, a test series was set up to determine the effect on quality of stowing fish and ice in plastic boxes stacked so the meltwater from the upper layers percolated down through the lower layers.

Results of a similar test have been reported by Houwing (1971); however, in his tests, the boxes were stacked four high compared with the stacks of nine boxes used in the tests reported here.

PROCEDURES

Polyethylene tote-boxes with a capacity of about 50 pounds of fish and 25 pounds of ice were used in these tests. After having been filled with eviscerated haddock (Figure 1) and flake ice, the boxes were stacked nine high in a cool room at 37°F (Figure 2). Control samples were pre-chilled fish, put in rectangular tins (Figure 3), covered, buried in ice, and held in the same storage room. Duplicate tests using the same procedures were conducted.

At intervals during the storage period, two fish were removed from the top, middle, and bottom tote-boxes and from the control tins and tested for total bacterial count and organoleptic acceptability.

For the total plate counts, a sterile 202 × 309 can, open at both ends, was

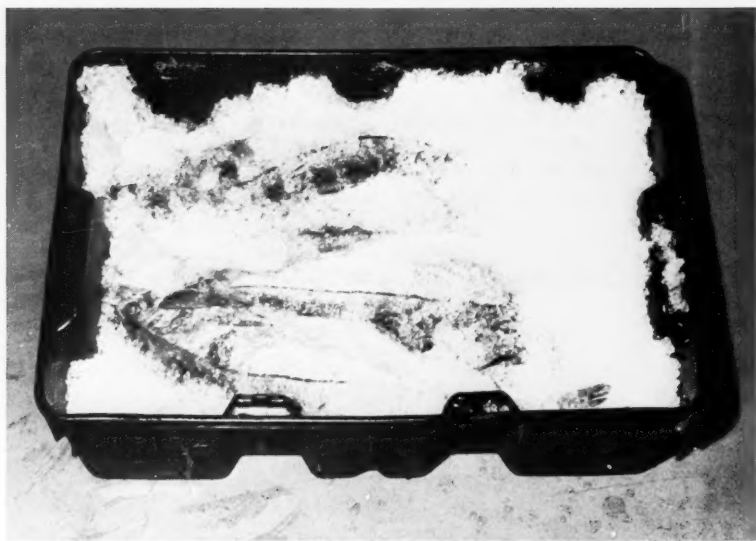
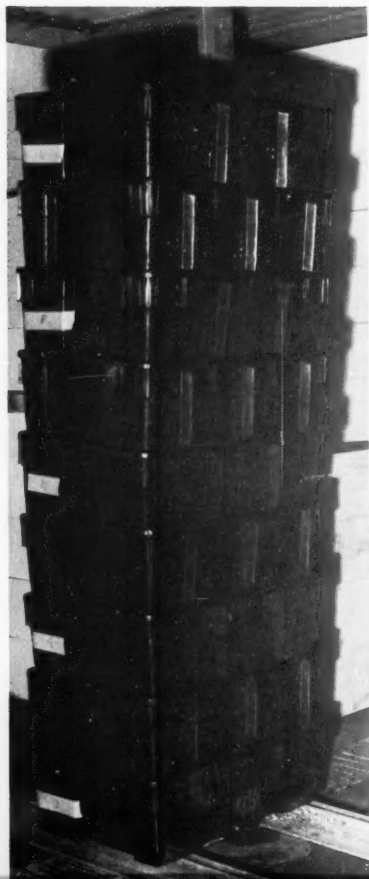


Figure 1.—Haddock packed with ice in plastic tote box.

Figure 2.—Tote boxes containing fish and ice stacked in cool room.



held tightly against the side of the haddock just posterior to the black spot, and 100 ml of sterile diluent poured into the can. A sterile glass pipette was used to scrape and lift the scales in the area surrounded by

the can. This was followed by rapid stirring to ensure complete mixing of the slime, etc., with the diluent. A one milliliter aliquot of this mixture was taken, appropriate dilutions made and plated in duplicate. The plates were incubated at 20°C for 5 days, the colonies counted, the results from the two fish averaged, and reported as numbers of bacteria per 3.5 square inches of fish surface.

For the organoleptic assessment, the fish used for determining total plate counts were filleted, skinned, cut into pieces, and steamed in a tightly covered pan. The Center's 12-member taste panel rated the fish on a 9-point scale for appearance, odor, flavor, and texture.

RESULTS

The results of the total plate counts are shown in Table 1. No statistically significant differences in counts as determined by analysis of variance are found that can be related to position of the fish in the stack of boxes.

The taste panel scores are shown in Table 2. Here again, there are no

Figure 3.—Control samples packed in 30-pound size cans.



statistically significant differences related to location in the stack of boxes.

CONCLUSIONS

For boxing fish at sea, inexpensive, readily available nest and stack tote-boxes which permit drainage of the melting ice down through the stack of boxes may be used without detriment to the quality of the fish. This fact clears the way for adoption of this technique by those vessel owners who have hesitated to make the investment in specially designed boxes of comparatively high cost.

The benefits will be improved quality of the fish as landed and increased yields in the processing plant.

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Table 1.—Total plate counts of fish stored in boxes.

Days on ice		Logarithms of Numbers of Bacteria per 3½ Square Inches							
		Control		Top Box		Middle Box		Bottom Box	
Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2
0	0	5.934	6.672	5.934	6.672	5.934	6.672	5.934	6.672
2	—	6.029	—	5.816	—	5.878	—	5.914	—
—	6	—	6.934	—	5.860	—	7.037	—	7.011
7	—	6.866	—	7.924	—	7.585	—	7.525	—
—	8	—	7.963	—	7.925	—	8.818	—	7.863
9	—	7.813	—	8.690	—	7.778	—	8.816	—
12	12	9.802	9.258	9.602	9.034	9.468	10.207	8.288	8.620

Table 2.—Taste panel scores on fish stored in boxes.

Days on ice		Taste Panel Scores ¹							
		Control		Top Box		Middle Box		Bottom Box	
Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2	Test No. 1	Test No. 2
—	1	—	8.75	—	8.75	—	8.75	—	8.75
3	3	7.38	6.75	7.75	7.10	7.05	7.68	6.07	6.68
6	—	—	6.32	—	6.38	—	6.87	—	6.93
—	7	7.13	—	6.97	—	7.19	—	7.40	—
8	—	—	6.80	—	6.90	—	4.00	—	6.07
—	9	6.00	—	6.35	—	6.30	—	6.95	—
10	—	—	5.14	—	4.63	—	6.35	—	6.06
13	13	4.42	4.28	4.95	4.93	6.06	3.00	6.40	4.37

¹ Based on a 9-point scale where 9 = Excellent, 8 = Very Good, 7 = Good, 6 = Fair, 5 = Borderline, 4 = Slightly Poor, 3 = Poor, 2 = Very Poor, and 1 = Inedible.

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Schoning Sees Fishery Export Opportunities

Economic growth and rising personal income in many countries have sent foreign buyers in search of new sources of fisheries products, and the United States is one of the sources, according to the Commerce Department's National Oceanic and Atmospheric Administration. A number of species found off the U.S. coasts are not fully utilized by U.S. consumers, yet the demand for these products is growing in foreign markets.

Robert W. Schoning, Director of NOAA's National Marine Fisheries Service, holds that much of the export opportunity lies in fish resources currently underutilized by this country. Examination of Japanese fish consumption data, for example, reveals that some of the major species consumed in Japan are listed as underutilized in the United States. Among these species are eel, squid, sea urchin, and croaker. The approximate annual per capita consumption of edible fish and shellfish in the United States in 1972 was 12.2 pounds, the highest in 45 years. Japan, on the other hand, had a per capita consumption of 70.8 pounds, down slightly, according to the latest available data (1970).

Schoning added that the growing world demand for fisheries products, the upward revaluation of foreign currencies, plus the devaluation of the U.S. dollar have combined to enhance U.S. export opportunities.

NMFS economists say that U.S. exports of fishery products have increased considerably in the past decade. Since 1962 the poundage of exported edible fishery products rose about 11 percent annually while imports were up about six percent annually. Still the dollar value of U.S. fishery products imported greatly exceeds the value of exports. In 1972 total U.S. imports of both edible and industrial fishery products were valued at about \$1.5 billion. The total value of exports (edible and industrial)

produced domestically was only \$158 million.

Squid, known to scientists as one of the cephalopods, offers an estimated peak allowable annual harvest of about 1.6 million pounds off the east coast of the United States, and is particularly popular in Mediterranean countries. The domestic market is limited. Atlantic herring has a high demand throughout Europe, and the U.S. export potential for herring fillets has been only partially realized, according to NMFS fisheries scientists.

The roe (eggs) of many fish is highly desired in some countries. Japan buys all herring roe produced in Alaska at present, as well as the majority of salmon roe from Alaska and the Pacific Northwest. A new market has been developed in Japan for sea urchin roe produced in California where that organism has long been considered a pest. NMFS economists believe that export values of Florida mullet could be tripled if the finished product (roe) were processed in the United States rather than selling the raw material, or whole fish, to Japan. Potential sales of processed mullet roe to Japan could reach 100 tons a year, according to the economists.

Moves are also being made by at least one important U.S. processor to divert part of the U.S. croaker production, most of which currently goes into pet food, into a high value human-consumption market abroad. In Japan, croaker surimi, a minced raw-fish product, is a delicacy, and Japanese croaker production is believed to have peaked.

Eels, little used in the United States, are imported in quantity by Italy and Japan. Silver and Pacific hake, heavily fished by foreign fleets, also probably have room for increased U.S. harvesting and export. Additional species with potential for expanded U.S. export opportunities are mussels, Pacific herring, Atlantic mackerel, and Alaska pollock.

NMFS Director Schoning points out that the fact that the foreign market exists does not mean that the U.S. fishing fleet is prepared to meet the demand immediately. He says that while the demand exists, there are possible problems of gear conversion, harvesting, and processing that must be overcome. The price that foreign buyers will pay for certain products also will help determine whether U.S. fishermen will expand their present fisheries to seek the currently underutilized species.

Coastal Zone Management Advisory Committee Established, Members Named

Secretary of Commerce Frederick B. Dent has announced the establishment of a Coastal Zone Management Advisory Committee and the appointment of fifteen distinguished persons to serve as members.

Purpose of the committee, as provided by the Coastal Zone Management Act of 1972, is to advise, consult with, and make recommendations to the Secretary on matters of policy concerning the coastal zone. It may draw upon the expertise of its members, or upon other individuals and groups, in the course of its work. Coastal zone matters relative to the Act that the

committee may deal with include implementation and administration of the Act; proposed legislation or revisions to the Act that appear to involve coastal zone policy; public awareness and concerns about specific management issues such as conservation, protection, and resource development; and Federal activities in the coastal zone related to administration of the Act.

The Committee will report to the Secretary through the Administrator of the National Oceanic and Atmospheric Administration. NOAA is

the action agency within the Department of Commerce for coastal zone management activities under the Act, and has established an Office of Coastal Environment to carry out this responsibility. Robert W. Knecht, Director of NOAA's Office of Coastal Environment, will serve as Chairman of the Coastal Zone Management Advisory Committee.

The Committee will meet twice a year, or more frequently if called upon by the Secretary or the Chairman of the Committee. Members of the Committee serve two-year terms, except that seven initial appointments are for one-year terms.

Members appointed for terms expiring in September, 1974 are:

Edward Bertrand of St. Thomas, U.S. Virgin Islands, General Manager of the Lagoon Marina in St. Thomas. He has been active in matters relating to the local port authority, and also served as Deputy Commissioner of the Department of Health.

Dr. William H. Fisher, Director, Bureau of Economic Geology, University of Texas. A well-known administrator associated with natural resource development and research, he has served on many Texas advisory bodies on the environment and natural resources.

Charles E. Fraser, President of the Sea Pines Company, a land development firm located on Hilton Head Island, South Carolina. He was a member of the President's Citizens Advisory Committee on Recreation and Natural Beauty from 1966 until 1969.

Dr. Charles E. Herdendorf III, Director of Ohio State University's Center for Lake Erie Area Research. He has spent a number of years working on the resources and problems of the Great Lakes, is a consultant to the Great Lakes Basin Commission, and is the author of numerous scientific publications.

Dr. Y. R. Nayudu, a marine geologist, Director of the Division of Marine and Coastal Zone Management of Alaska's Department of Environmental Conservation. He is a

NMFS Biologists Assist Science Students

Biologists from the National Marine Fisheries Service's Auke Bay (Alaska) Laboratory are assisting students of the Auke Bay Elementary School in a science project involving the field testing of gravel incubation of pink salmon eggs. The fourth, fifth, and sixth grade classes of the Auke Bay school have installed a 1/4-inch pipeline in a small spring-fed stream near the school, and each class has a 1-cubic-foot NMFS-style incubator connected to the water supply.

With the help of the Laboratory biologists, the students collected eggs from Auke Creek on September 17, 1973 and buried about 2,000 in each incubator. One of the incubators, a transparent model, will be inspected periodically to

follow the process of embryo development in the gravel. The students hope to keep the pipeline flowing all winter and to observe the emergence of live, healthy pink salmon fry this spring.

As an orientation for the project, nine classes of about 30 students each, with their teachers and their principal, Hal Vrooman, visited the Auke Bay Laboratory's experimental incubation station at Auke Creek on September 14. Coordination of this and similar projects at other schools in southeastern Alaska is under the Alaska Department of Fish and Game's Division of Fisheries Rehabilitation and Enhancement. The NMFS biologists are providing technical guidance to the teachers and students.

Science Advisor to the Governor of Alaska, and was designated by the Governor's Office as the Alaskan point of contact for the Coastal Zone Management Program.

John Spellman, County Executive of King County, Washington, the county surrounding Seattle. He is an attorney who has been admitted to practice before the U.S. Supreme Court, and the Washington State Supreme Court. He was formerly Vice President of the Seattle-King County Economic Development Council.

Scott C. Whitney, a Professor of Law and Director of the environmental law program at the College of William and Mary in Williamsburg, Virginia. He is also a practicing attorney, specializing in environmental law.

Members appointed for terms expiring in September, 1975, are:

Harry C. Brockel, retired Director of the Port of Milwaukee and currently a lecturer at the University of Wisconsin's Great Lakes Study Center. He has served in numerous capacities associated with ports and shipping in

the Great Lakes for the city of Milwaukee and the State of Wisconsin.

Robert Bybee, Operations Manager of the Exxon Company's Exploration Department. He has had considerable experience in geology and oceanography, and has been active in and an officer of numerous organizations and societies associated with oceanography and petroleum.

William B. Hannum, Jr., President of Sea Farms, Inc., of Key West, Florida. In addition to business involvement in fisheries, he recently served on the Department of Commerce's Marine Fisheries Advisory Committee, which addresses the national problems and needs in the area of marine fisheries.

Ellen Stern Harris, Vice Chairman of the California Coastal Conservation Commission. She serves on the Task Force on the Environment for the California Attorney General, and is a consumer advocate columnist for the Los Angeles Times. She has served on numerous boards and committees concerned with the environment and conservation.

Dr. Lee Koppelman, Executive Director of the Nassau-Suffolk (N.Y.) Regional Planning Board. He holds adjunct professor posts in planning and political science at two local universities. A well-known regional planner, he has published text books on planning and is a member of several professional organizations on planning.

Dr. Lyle S. St. Amant, Assistant Director of the Louisiana Wildlife and Fisheries Commission. He is nationally recognized for his efforts to bring balanced utilization to the coastal environment of Louisiana and is Chair-

man of the Louisiana Advisory Commission on Coastal and Marine Resources.

W. Reid Thompson, President of the Potomac Electric Power Company and formerly General Counsel and later executive Vice President of Carolina Power and Light Company.

Peter Wilson, mayor of San Diego and a former member of the California Assembly. He authored the first coastal protection legislation to be introduced in the California legislature. Mayor Wilson also served on the President's Citizens' Advisory Committee on Environmental Quality.

U.S., USSR Opt for Joint Marine Monitor

United States and Soviet marine scientists have signed an accord aimed at the establishment of a joint marine environmental monitoring network, according to the Environmental Protection Agency. The network, when established, will make it possible to measure the effects of pollution on marine organisms on a continued basis and to disseminate the related data rapidly.

The pact was signed in Moscow on October 27, 1973 following almost two weeks of discussions held by the U.S.-USSR Joint Working Group on the Effects of Pollutants on Marine Organisms. An earlier meeting of the two teams of marine experts was held in the U.S. in May 1973.

The cooperative program between the two countries is being carried out under the terms of the environmental pollution accord signed by President Nixon and Soviet Chairman Podgorny in May 1972.

The protocol sets forth the first two steps that both sides will undertake in developing the proposed marine monitoring system. The first step calls for a marine journal to be published simultaneously in the U.S. and USSR in English and Russian, respectively. To be issued bimonthly, this will be the first scientific journal to be pub-

lished simultaneously in the two countries, and will contain articles reflecting the highest level of marine research being conducted in the U.S. and USSR.

The second step provides for the establishment of a scientist exchange program. Under this program, as many as 10 marine scientists from each of the two countries will exchange visits each year to lecture and to become acquainted with the state of the art in marine research in the host country. During the early stages of the program, emphasis will be placed on research methodologies.

The American delegation that participated in the discussions which led to the protocol was headed by Dr. Eric D. Schneider, Director of EPA's National Marine Water Quality Laboratory at Narragansett, Rhode Island. The Soviet experts were headed by Dr. V. D. Fedorov, Chairman, Department of Hydrobiology at Moscow State University.

Federal Funds Help Restore Gulf Oysters

Funds totaling \$213,620 for the restoration of oyster resources in Alabama, Louisiana, and Mississippi were made available to those States

last fall under the provisions of the Commercial Fisheries Research and Development Act (PL 88-309) as amended.

The funds were awarded by the Commerce Department's National Oceanic and Atmospheric Administration to assist the three States in the rehabilitation of coastal oyster beds heavily damaged by the disastrous spring floods last year in the Gulf States.

Apportionment of the funds was on the basis of the extent of the destruction of oyster reefs in each of the three States. Alabama received \$79,040, Louisiana \$85,448, and Mississippi \$49,132. Funds are administered through NOAA's National Marine Fisheries Service under grant-in-aid awards from the NMFS Southeast Regional Office, St. Petersburg, Florida. Additional funding, requested in the amount of \$482,396, is under consideration by Federal authorities.

The oyster resources involved in the natural disaster represent a \$5 million contribution to the economy of the three States, and are an important part of the national supply of marine food. Flooding by muddy fresh water entering the grounds on which the oysters are cultivated resulted in heavy deposits of silt and growth of marine organisms on the material (called "cultch") which furnishes points of attachment for baby oysters, or spat. Unless new cultch is promptly planted, growth and development of new oyster generations can be seriously inhibited and future supplies of the valuable crop endangered.

To qualify for funds specifically authorized under Section 4 (b) of PL 88-309 to alleviate resource disasters, a State must clearly demonstrate that a commercial fishery failure has occurred owing to natural or undetermined causes. A declaration of eligibility concerning the three-State need for assistance in disaster was published in the Federal Register on September 14, 1973. The funds were released to the State fishery agencies on October 2, 1973.

Favorite Awarded Commerce Medal

Felix Favorite, a supervisory oceanographer with the National Marine Fisheries Service's Northwest Fisheries Center, Seattle, Wash., has received the Department of Commerce Silver



Favorite

Medal for his major contribution to fishery and oceanographic science particularly in relation to the Alaskan Stream. Secretary of Commerce Frederick B. Dent presented the award in a ceremony in Washington, D.C.

Favorite was cited for his extraordinary organizational ability and technical competence in the planning and execution of oceanographic programs that have done much to interpret the marine environment in the North Pacific. Oceanographic investigations conducted by personnel at the Center under his supervision have provided a rational basis for explaining the relationship between fish (particularly salmon) and their environment. His ability to integrate biological and environmental observations was of major value to planners of underground nuclear testing in the vicinity of Amchitka Island in the Aleutians.

Born in 1925 at Quincy, Mass., Favorite was graduated from the Massachusetts Maritime Academy in 1944 and earned his B.S. in marine science at Boston University in 1950. He received another B.S. (oceanography) from the University of Washington in 1956 and his M.S. from the same university in 1966. He was awarded his Ph.D. by Oregon State University in 1968.

Favorite entered the Federal service in 1953 after serving as a ship's officer with an unlimited Master's license while working for a private steamship line. He has been stationed at the Center since 1956, when the Center's

oceanographic investigations of the North Pacific began under his direction. Performing as a teaching and research assistant at the University of Washington during 1956-57, Favorite was named to his present position as oceanographer in 1957.

INPFC Concludes 20th Annual Meeting

The International North Pacific Fisheries Commission, whose members represent Canada, Japan, and the United States, concluded its 20th Annual Meeting at Tokyo, Japan, on Nov. 9, 1973. The meeting extended over three weeks, with two weeks of scientific sessions preceding the week of plenary sessions. Mr. Kenjiro Nishimura of Japan was chairman of the Commission at this meeting.

The Commission reviewed the results of conservation programs and scientific research on North Pacific fishery resources. Approximately 100 administrators, scientists, and industry advisers took part in the discussions, which dealt primarily with the general problem of ensuring the continued orderly development of the North Pacific fisheries resources with a view to maintaining maximum sustainable yields. As in past years, the Commission was assisted in certain of its discussions by consultants from the International Pacific Halibut Commission.

The Commission adopted a resolution recommending that the governments of the Contracting Parties give full consideration to the conservation needs of salmon stocks in areas of intermingling when preparing fishing regulations for future operations. The resolution also pointed out the necessity of giving special attention to the implementation of adequate conservation regulations with regard to salmon, as reflected in the patterns of fishing activities.

In the case of certain fishery resources which are exploited by fishermen of two or more of the member countries, such as king crab and tanner crab resources of the eastern Bering

Sea and groundfish other than halibut in the northeastern Pacific Ocean, scientific studies are being continued.

Conservation measures for halibut fishing in the eastern Bering Sea for 1974 were again considered by the Commission. Such recommendations have been made annually since 1963. However, the three national sections did not reach agreement and no recommendations were forthcoming from this meeting.

The Commission reviewed progress in publication of scientific research results and preparation of joint comprehensive reports on salmon as well as compilations of historical salmon and groundfish statistics. Tentative plans for research in 1974 were exchanged between the national sections.

The annual meeting in 1974 will be held in Seattle, Washington beginning on November 4. Officers elected for 1974 are Mr. Elmer E. Rasmuson of the United States, Chairman; Mr. C. R. Levelton of Canada, Vice-Chairman; and Mr. Kenjiro Nishimura of Japan, Secretary.

Source: International North Pacific Fisheries News Release, Nov. 9, 1973.

NMFS Scientists Receive National Publication Awards

Scientific papers written by three National Marine Fisheries Service biologists, have won two of six top national fisheries publication citations including the American Fisheries Society's 1973 Best Paper Award. In all, 65 full-length papers were considered by the AFS Awards Committee.

"Reduction in Stocks of the Pacific Ocean Perch, an Important Dermal Fish Off Alaska," a paper by Jay C. Quast, was chosen as the best scientific paper published in the 1972 Volume (Vol. 101, pp. 64-74) of the *Transactions of the American Fisheries Society*. Quast is a biologist at the NMFS's Auke Bay (Alaska) Laboratory.

Two other NMFS scientists, Fred M. Utter and Harold O. Hodgins, at the Northwest Fisheries Center, Seattle, Wash., received one of the five

AFS Honorable Mention awards for their paper, "Biochemical Genetic Variation at Six Loci in Four Stocks of Rainbow Trout," (*Transactions* pp. 494-502).

Quast, in his paper, states that stocks of Pacific ocean perch have been steadily declining since 1963 when

the species began to be heavily exploited by foreign trawl fisheries, particularly those of the Soviet Union and Japan. He detailed the need for international efforts to preserve the stocks and suggested that it may already be too late for successful rehabilitation.

ICNAF Pact is Hailed as a Major Step in Northeast Atlantic Fisheries Stewardship

Secretary of Commerce Frederick B. Dent has said that an international agreement reached last fall brings new hope for the gravely-depleted fishing grounds off the northeastern United States.

The pact, at an October 15-20 meeting in Ottawa of the International Commission for the Northwest Atlantic Fisheries, not only represents a major step in fisheries stewardship but substantially improves the prospects of the hard-pressed New England fishing industry, he said.

"This agreement reverses a perilous trend toward further depletion of the stocks and institutes a policy which should permit the fishery not only to survive but to recover to a state of health," the Secretary said. "Further, it is notable in that, for the first time in marine fisheries history, an agreement encompasses an entire ecosystem instead of being limited to individual species."

Last June Secretary Dent, disturbed at foreign over-fishing and the lack of progress in the ICNAF, called in urgent terms for major reductions in foreign fishing off our shores, and recommended that unless that organization moved to end over-exploitation the U.S. should seriously reconsider whether it should retain ICNAF membership.

He extended congratulations to the United States Commissioners to ICNAF—Ambassador Donald McKernan of the State Department, David H. Wallace, Associate Administrator for Marine Resources of the Commerce Department's National Oceanic and Atmospheric Administra-

tion, and Ronald Green of Maine, industry representative. "Their dedicated and persuasive negotiation accomplished a tremendous victory for conservation," Secretary Dent said. "We are also highly appreciative of the cooperation and understanding shown by all member states of ICNAF. We are convinced the agreement will benefit all nations which fish these grounds—not just the United States."

The participating nations agreed unanimously (with Romania abstaining) to a three-year series of reductions from current levels, estimated at a total catch of 1,180,000 metric tons of all species for all countries, for 1973. The 1972 catch was 1,188,000 metric tons.

The total catch in 1974 would be reduced to 923,900 tons; the 1975 catch to 850,000 tons; and the 1976 catch will be set on the basis of information gathered in 1974 and 1975. The third-year figure is anticipated to bring the ecosystem to total recovery.

It was further agreed that vessels over 145 feet long (few of which are U.S.-operated) will refrain from bottom-fishing between July and December of each year in an area off

New England. The practice will allow stocks of yellowtail flounder, a major Massachusetts fishery, and young haddock, which are seriously threatened, to regenerate.

It was agreed that the reductions would not be at the expense of U.S. fishermen. The total quota for fishing, in the area off the East Coast between Canada and Cape Hatteras, allows for a small increase in catches for the coastal fisheries of the United States and Canada. The U.S. quota for 1974 will be approximately 195,000 tons. In recent years, the U.S. catch has declined dramatically, while those of foreign nations have ballooned.

The 1974 overall catch in metric tons, by nation, will be:

United States	195,000
USSR	342,500
Poland	152,200
Bulgaria	29,100
Canada	25,000
EED, Rep. Germany	27,000
Italy	4,700
Japan	24,300
Romania	4,300
Spain	17,200
German Dem. Rep.	97,600
Others	5,000
Total	923,900

The United States' share of individual species will be: cod, 25,267; redfish, 24,747; silver hake, 38,300; red hake, 15,000; pollock, 12,000; yellowtail, 24,000; other flounders (except yellowtail), 21,700; squids, 5,600.

The USSR's share will be: cod, 2,463; redfish, 1,725; silver hake, 113,056; red hake, 32,000; pollock, 2,100; other flounders (except yellowtail), 2,600; squids, 8,500.

Canada's share is: cod, 4,820; redfish, 414; pollock, 34,000.

NMFS Researcher Identifies 20 Previously Unknown Free-Living Marine Amoebas

A Commerce Department scientist conducting the first major study of marine amoebas in almost a half century has identified 20 previously unknown species.

Marine amoebas may prove highly useful as environmental indicators of

oceanic pollutants.

Amoebas are microscopic one-celled animals that exist primarily in water or soil, or as parasites in other animals and plants. While the majority of them are harmless, some cause diseases in humans such as amoebic

dysentery and certain kinds of brain damage. Others may infect animals or plants. Little is known of marine amoebas.

Thomas K. Sawyer, a marine biologist with the National Oceanic and Atmospheric Administration, conducted a year-long study of free-living (non-parasitic) marine amoebas in Chincoteague Bay, Virginia, to provide baseline data for future comparative studies in marine habitats that have specific pollutant problems. Studies of amoebas in the essentially unpolluted waters of Chincoteague Bay, Sawyer believes, will provide information on natural diversity and types of amoebas against which later studies of polluted waters can be measured.

The total number of species of marine amoebas presently known is about 75. Sawyer, who is a staff member of NOAA's National Marine Fisheries Service Laboratory at Oxford, Md., concludes from his study that:

1. Amoebas are extremely abundant in the ocean, both crawling on seaborne vegetation and floating in surface waters;
2. The diversity of species of marine amoebas is poorly known and needs intensive study, particularly with respect to such aspects as the role they play in the biodegradation of pollutants and as consumers of marine bacteria;
3. Of the known marine amoebas, about half the species probably are unable to tolerate the pollution caused by man's effluents.

In his study, Sawyer identified 35 species of free-living amoebas from Chincoteague Bay, of which 20 were new species. Among the known species were several that are believed to cause diseases in aquatic plants or animals. As yet there is no evidence to show whether any of the newly-identified species are potentially harmful.

Sawyer points out that there are two approaches to the use of amoebas as oceanic environmental indicators. Where it is known that a widespread species of free-living amoeba cannot tolerate certain kinds of pollutants, the absence of such amoebas in particular waters would point to the presence

of such pollutants. Conversely, some species of amoebas thrive on certain kinds of pollutants—for example, some are found in superabundance in freshwater sewage sludge—and the presence of these species would point to the presence of certain pollutants.

In the latter case, the amoebas accompanied by bacteria, fungi, and other protozoans serve a highly useful function as agents for biodegradation of the pollutants—that is, for decomposing them and thus rendering them less harmful.

Protozoa, a classification of one-celled animals that includes amoebas, have been studied intensively in sewage in freshwater. The studies of the National Marine Fisheries Service are extending the work into the marine environment. Protozoa are among the first organisms in the food web that use bacteria for food.

The last major study of marine amoebas in this country was undertaken by Prof. Asa Schaeffer, who published his findings in a monograph of the Carnegie Institution of Washington in 1926. Subsequently a number of studies of specific problems have added somewhat to the sparse knowledge of marine amoebas. In 1969, Victor Sprague and Robert L. Beckett of the Chesapeake Bay Biological Laboratory, Solomons, Md., and Thomas Sawyer of NMFS carried out a cooperative study of an unusual parasite found in the blood and internal organs of blue crabs. It was found in dead or dying crabs, said by the watermen who found them to have "gray crab disease." The parasite, identified as a new species of amoeba, was an important factor in crab mortality and caused an appreciable seasonal economic loss to the industry. This crab parasite did not present a human health problem.

Two years later, Sawyer participated in a cooperative study of amoebas living on the gills of fingerling trout and salmon. In some cases, the fish showed evidence of suffocation, apparently suffering from amoebic

gill infection. Attempts to control the loss of fish in State hatcheries were successful after diluted Formalin was added to the water. Further work on marine amoebas is now being undertaken in conjunction with NOAA's Marine Eco-Systems Analysis (MESA) program.

Open-Mouth Swim Mechanism Is Studied

Some fishes such as the sea bass actively move their gill covers to obtain oxygen from the water. Other fish such as the sockeye salmon can suspend active breathing movements when swimming at speeds just under one mile per hour or higher and switch to "over-drive", which is open-mouth swimming, or what fishery biologists call ram-gill ventilation. Once tunas and their close relatives, the mackerel-like fishes, reach adult size, however, they can only survive in the "over-drive" method of ventilating their gills by maintaining continuous swimming activity at speeds near one mile per hour to save energy and improve efficiency.

What mechanisms control the transfer to open-mouth swimming in fishes? This is the question which John Roberts, physiologist and Professor of Zoology at the University of Massachusetts is trying to answer this year at the National Marine Fisheries Service (NMFS) laboratory at La Jolla, California.

Roberts, 51, is a recipient of a National Research Council Senior Research Associateship, awarded by the NMFS, an agency of the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce. According to Brian J. Rothschild, Director of the NMFS Southwest Fisheries Center in La Jolla, the annual award at the Center provides an opportunity for postgraduate scientists to work on basic research problems with professional staff at the laboratory. Roberts, author of many papers on gill ventilation in fishes, plans initially to record activity

from respiratory centers in swimming fish, such as mackerels, as the animals reach a speed at which the change from active to ram-gill ventilation occurs.

At the La Jolla facility, Roberts has access to one of the largest and best-equipped sea-water research aquarium laboratories in the world. Under Reuben Lasker, physiologist at the La Jolla Laboratory, a broad program of research on the physiology of marine fishes and their food organisms is in progress. Staff scientists there are measuring the effects of such environmental factors as salinity and temperature on the growth and survival of larval fishes, exercising large fishes in special tanks to observe physiological and behavioral changes, and developing successful techniques for spawning and rearing a variety of marine fishes for experimental work and mariculture. Lasker explained that Roberts' study will contribute important information on the effects of environmental factors on the survival, metabolism, and growth of fishes, particularly the family of fishes that includes the mackerels and tunas.

Foreign Fishery Developments

Canada Sets Atlantic Fishing Fleet Policy

A new fishing fleet development policy for Canada's Atlantic coast, aimed at matching fleet size to fish stocks by instituting a more selective subsidy program for vessel construction and by establishing a new license control program, was announced in mid-November by Fisheries Minister Jack Davis. The new policy ended a three-month freeze on construction subsidies and new vessel licenses announced by the Minister on August 13.

The three-month freeze was intended to give federal authorities time to fully assess the situation, in consultation with provincial governments, industry and fishermen. The consultations produced the decision to match more

closely the size of the fishing fleet to the stocks of fish available to Canadian fishermen. Where the fisheries resources are already fully exploited, the fishing effort will be controlled. Where it is in Canada's interest, as in the international fishery off the coast, expansion will be encouraged.

"Our share of international quotas in these areas will further increase only as our catch increases," Davis said. "Therefore, we must ensure that our catching capacity is encouraged and allowed to expand to provide us with larger shares of the available resources."

The new policy calls for special committees, representative of all fishery interests, to advise the management authority on all licensing matters. The committees will involve fishermen directly in the management of local fish resources.

U.S., Mexican Shrimp Prices Affect Japan

The high price of U.S. and Mexican shrimp of November 1973 was expected to affect the market price in Japan according to World Wide Information Services, Inc. Inspectors from the Tsukiji Fish Market went to Mexico City and Los Angeles to inspect the markets there. Full utilization of available supplies in those markets would reportedly make it difficult for the Japanese to import shrimp from there. Other sources of supply are being developed.

Of the 10,185 short tons of frozen shrimp imported by Japan in September, 1,936 short tons came from India, 347 short tons from Cuba, 293 short tons from Brazil, 709 short tons from Taiwan and 151 short tons from New Zealand. The trend of imports shows a decrease from Indonesia and an increase in shrimp from Brazil and Cuba. Japan had imported 55 tons of a type of shrimp (taisho-ebi) from China since August. The largest sizes were reported to sell for \$8.23 per pound. Frozen shrimp from Mexico brought \$2.96 per pound.

Japanese Fishermen Begin To Lease Boats

The Fishery Agency of Japan has started a system of leasing boats to fishermen in Yamaguchi Prefecture on a trial basis, reports World Wide Information Services, Inc. If successful, fishermen throughout the country may start using boats under lease instead of investing a large sum for building them.

The agency said the lease system was begun because the financial burden had increased owing to rising costs of building and incessant demand for modernization of fishing craft. It hopes the system will speed up the modernization of fishing technology and improve working conditions. The boats will be leased to fishermen under contracts valid from three to nine years. The boats will be made with fiberglass reinforced plastics and will be less than 10 tons each.

Norway's Fishery Exports Increase

Norway's Ministry of Fisheries estimates that Norwegian exports of fish and fish products for 1973 would be worth 3,100 million kroner (about \$554 million), an increase of 600 million kroner compared with 1972, according to a report in Norway Trade News. The increase is chiefly due to exceptionally high prices for fish meal, oil, and hardened fats, but prices for fish generally have also shown marked improvement.

Publications

New Editions of NOS Charts Are Available

New editions of charts cancel former editions. Mariners are warned against the use of obsolete charts as new editions contain information essential to safe navigation. Charts

may be purchased from Director, National Ocean Survey (formerly Coast and Geodetic Survey), National Oceanic and Atmospheric Administration, U. S. Department of Commerce, and its authorized sales agents.

1. **New York Harbor**, 62nd edition of Chart No. 369 (N.O. 12141), issued

Sept. 15, 1973, scale of 1:40,000. Price \$1.75.

2. **Florida—Everglades National Park—Shark River to Lostmans River**, 6th edition of Chart No. 599SC (N.O. 11154), issued Sept. 15, 1973, scale of 1:50,000. Price \$2.20.

3. **Hawaii—Hawaii to Oahu**, 16th

edition of Chart No. 4116 (N.O. 19060), issued Sept. 15, 1973, scale of 1:250,000. Price \$1.75.

4. **Alaska—Southeast Coast—Southern Entrances to Summer Strait**, 6th edition of Chart No. 8173 (N.O. 17103), issued Sept. 22, 1973, scale of 1:40,000. Price \$1.75.

Monthly Fishery Market Review

September Groundfish Supplies High as Landings Gain

FILLET SUPPLIES CONTINUE HIGH

Supplies of groundfish fillets (cod, flounder, haddock, and ocean perch, Tables 1-5) continued high during September, but some notable changes in the components of supply occurred. First, landings recorded one of the few gains this year with a 16 percent increase to 5.7 million pounds. Increased catches of from 40 to 25 percent in the cod and flounder fisheries, respectively, were responsible for the September advance.

Second, imports fell during the month after eight consecutive monthly increases this year. The lower quantity of cod received this month (4 million pounds less) was primarily responsible for the overall decline, although both flounder and haddock imports were also down. The decline may be tied to a drop in the quantity caught in Canada (our major supplier) during September, and some redirection of supplies from the United States to European markets where high demand and prices have attracted additional quantities.

In spite of the higher total quantity of fillets available, consumption dropped about 5 percent to 28.8 million pounds. This appears to have been in response to an increasing level of fish prices in conjunction with declining prices for some meat and poultry products. Except for cod and flounder ex-vessel prices, almost all fillet prices rose during the month (Table 6).

Table 1.—Groundfish supplies (fillet weight in million pounds), September 1973. Groundfish include cod, flounder, haddock, and ocean perch.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	42.6	47.5	49.1	33.5	+47	52.4	45.0	+16
Total landings	4.6	4.2	5.7	4.9	+16	47.7	52.2	-9
Imports	25.9	32.1	29.3	34.3	-15	235.4	208.6	+13
Total supply	73.1	83.8	84.1	72.7	+16	335.5	305.8	+10
Ending inventory	47.5	49.1	55.3	42.4	+30	56.2	42.4	+30
Consumption	25.6	34.7	28.8	30.3	-5	279.3	263.4	+6

Table 2.—Cod supplies (fillet weight in million pounds) in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	15.7	14.7	15.5	14.8	+5	16.2	6.1	+166
Total landings	1.0	1.0	1.4	1.0	+40	10.9	10.7	+2
Imports	5.8	7.5	5.2	8.9	-42	67.0	80.5	-17
Total supply	22.5	23.2	22.1	24.7	-11	94.1	97.3	-3
Ending inventory	14.7	15.5	14.8	16.2	-9	15.7	16.2	-3
Consumption	7.8	7.7	7.3	8.5	-14	78.4	81.1	-3

Table 3.—Flounder supplies (fillet weight in million pounds) in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	8.4	9.6	9.6	4.7	+104	8.6	9.3	-11
Total landings	2.1	1.9	3.0	2.4	+25	21.3	22.9	-7
Imports	6.6	8.8	8.7	9.3	-6	71.3	53.1	+34
Total supply	17.1	20.3	21.3	16.4	+30	101.2	85.3	+19
Ending inventory	9.6	9.6	10.6	5.7	+66	10.6	5.7	+86
Consumption	7.5	10.7	10.7	10.7	—	90.6	79.6	+14

Table 4.—Haddock supplies (fillet weight in million pounds) in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	8.3	8.8	8.8	4.5	+96	9.8	8.9	+10
Total landings	0.3	0.3	0.1	0.3	-77	2.5	3.3	-24
Imports	3.3	4.3	3.6	4.4	-18	32.5	25.9	+25
Total supply	11.9	13.4	12.5	9.1	+37	44.8	38.1	+18
Ending inventory	8.8	8.8	9.8	7.1	+38	9.8	7.1	+38
Consumption	3.1	4.6	2.7	8.0	-66	35.0	31.0	+13

BLOCK IMPORTS DOWN, STICK AND PORTION PRODUCTION STABLE

U.S. imports of fish blocks declined sharply in September to 33.6 million pounds, 9 million pounds less than the previous month but about a fourth higher than last September (Table 7). Prices of all major fish blocks (Table 8) showed sharp increases in September, and although prices for fish sticks and portions also rose, they were not sufficient to halt the continuing cost squeeze faced by domestic stick and portion producers (Tables 9 and 10). In order to realize even the minimum 10-cent margin on cod portions, for example, domestic firms would have to produce portions from cod blocks imported in April when the blocks were selling for 58.5 cents per pound. By September, cod block prices were up to 78.5 cents, almost 10 cents per pound higher than the cod portion prices.

Total stick and portion production was practically unchanged from the previous month, but 23 percent above the same month in 1972. Block inventories on October 1 were running about 40 percent below the levels of a year ago. In light of reduced imports, domestic producers were apparently drawing more heavily on existing stocks to meet the fall market demand from institutional users. As a result, stocks at the end of September were 7 percent lower than at the beginning of the month.

SHRIMP SUPPLIES SHORT, PRICES RISE RAPIDLY

The supply situation in the shrimp industry continued to be short during September (Table 11). Based primarily on low cold storage holdings, total supplies available for consumption during the month were 30 percent below the previous year. Total supplies available through the first three quarters of 1973, however, were not as short as current supplies, falling only 6 percent below the same period

in 1972. Because holdings were drawn down rapidly in the first half, continued low landings (particularly in the Gulf) and imports resulted in the lower 9-month total.

In spite of the overall shortage, there are some bright spots in the supply picture this month. Gulf landings continue to feel the effects of the spring floods; however, the gain registered in the Pacific catch more than offset that decline. Oregon has had a record catch this year and Alaska landings during the month were about four times the quantity

landed in 1972. Furthermore, the import situation appears to be improving. The Japanese, who provide our major competition for world shrimp supplies, apparently have curtailed their purchases in recent months because of high supplies and declining pricing in that country. As a result, imports have improved considerably and were only slightly below the quantity received last year.

Owing to the general shortage of supply, prices have increased rapidly (Table 12). The wholesale prices for 15-20 count shrimp, for example, rose

Table 5.—Ocean perch supplies (fillet weight in million pounds) in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	10.2	14.4	15.2	9.5	+60	17.8	20.7	-14
Total landings	1.2	0.9	1.2	1.3	-8	13.0	15.3	-15
Imports	10.2	11.5	11.8	11.7	—	64.6	49.1	+32
Total supply	21.6	26.8	28.2	22.5	+25	95.4	85.1	+12
End inventory	14.4	15.2	20.1	13.4	+50	20.1	13.4	+50
Consumption	7.2	11.6	8.1	9.1	-11	75.3	71.7	+5

Table 6.—Groundfish prices (wholesale, FOB Boston, Gloucester, and New Bedford in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
	Cents Per Pound				Percent	Cents Per Pound		Percent
Cod								
Ex-vessel ¹	18.9	20.1	18.4	19.4	-5	19.9	19.7	+1
Wholesale								
1 lb Canadian	65.1	71.8	78.8	56.5	+39	64.4	55.3	+17
5 lb Canadian	64.0	67.1	73.5	54.5	+35	60.0	54.4	+10
Retail ²	170.0	179.3	180.0	137.8	+31	178.7	130.3	+38
Flounder								
Ex-vessel								
Yellowtail	19.90	24.47	13.84	18.27	-24	22.90	19.22	+19
Lemonsale	52.00	64.52	34.27	37.31	-8	44.61	39.07	+14
Greysale	29.17	32.44	31.09	25.45	+22	29.70	25.25	+18
Blackback	30.02	38.62	20.95	24.85	-16	27.90	27.46	+2
Wholesale								
5 lb domestic	87.5	3	92.5	98.8	-6	94.2	89.8	+5
5 lb Canadian	81.8	83.2	84.9	72.9	+16	80.6	61.4	+31
Retail ²	219.4	231.6	227.5	166.5	+37	218.2	163.9	+33
Haddock								
Ex-vessel ¹								
Large	49.5	52.6	54.0	41.7	+30	47.4	41.2	+15
Scrod	22.9	25.5	26.5	28.8	-8	26.9	32.2	-17
Wholesale								
5 lb Canadian	83.7	83.0	88.0	77.5	+14	80.7	65.8	+23
Retail ¹	133.6	136.3	136.5	108.4	+26	127.5	104.5	+22
Ocean Perch								
Ex-vessel ¹	7.6	8.3	8.9	6.4	+39	7.6	5.6	+36
Wholesale								
5 lb domestic	58.0	63.8	68.9	55.0	+25	60.8	67.6	-10
5 lb Canadian	55.8	59.5	62.5	47.1	+33	55.4	42.4	+31
Retail ¹	99.8	100.7	102.6	78.0	+32	96.0	74.5	+29

¹ Quotes taken at Boston, Mass.

² New York Consumer Market Reports.

³ No quotes during September 1973.

⁴ Bureau of Labor Statistics (average of 36 U.S. cities).

more than 50 percent since the start of the year. Prices at all levels were well above the previous. As a result of the increases in shrimp prices (retail prices for 15-25 count, shrimp rose 44 cents per pound in September) and the 0.7 percent drop in average grocery store food prices, including lower prices for many meat and poultry items, consumption of shrimp was off 14 percent from the previous year and about 25 percent from August.

SCALLOPS SUPPLIES HIGH

Supplies of scallops continued to be high during September, reflecting the large quantity in inventory (Table 13). Landings were practically the same as in 1972, but imports dropped off sharply. This month's decline in imports was primarily the result of lower shipments received from Canada. The combination of lower landings and inventories in Canada during September apparently has limited the quantity available for export.

Prices at the ex-vessel and wholesale levels stabilized during the month in the wake of sharp increases because of the New Bedford strike in August (Table 14). Retail prices, however, rose rapidly during the month from \$2.51 per pound in August to \$2.84 in September. In spite of the higher retail prices, demand was strong as consumption was 27 percent above the previous year. Nearly all the new supplies were consumed and the quantity in storage was practically unchanged.

AMERICAN LOBSTER SUPPLIES DOWN

Available supplies of American lobsters were well below the previous year in September on the basis of lower landings and imports (Table 15). Maine landings were down 1.3 percent from September 1972, but were double the quantity caught in July and about 10 percent above August landings. Imports from Canada were off about 11 percent during the month. Most of this decline can be attributed to the lower quantity landed in Canada this year (down

about 3 million pounds through August).

With supplies off and demand apparently strong, wholesale prices remained high, although down somewhat from the previous month (Table 16). After peaking in August, following an average increase of 58 cents per pound, prices slipped to an average of \$2.60 per pound for 1¼ pound lobsters. This decline probably reflects the increase in landings of earlier months, but was undoubtedly tempered by the overall decline in supplies this year.

DEMAND HIGH FOR SPINY LOBSTERS

The supply picture for spiny lobsters was one of steadily declining imports, high demand and a drawing down of inventories (Table 17). Imports have been consistently below the previous year throughout 1973, and September was no exception. Lower shipments from Brazil, Australia, and New Zealand were primarily responsible for the September decline.

Inventories, which had begun the year 89 percent above the previous

Table 7.—Supplies of blocks and slabs in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan-Sept 1973	Jan-Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	33.1	48.8	64.5	93.8	- 32	75.8	62.7	+ 21
Production	0.3	0.5	0.6	0.2	+100	3.9	1.5	+160
Imports	27.4	42.9	33.6	26.5	+ 27	247.7	286.1	- 13
Total supply	60.8	92.2	98.7	120.5	- 18	327.4	350.3	- 7
Ending inventory	48.8	64.5	60.8	104.4	- 42	60.8	104.4	- 42
Consumption	12.0	27.7	37.9	16.1	+135	266.6	245.9	+ 8

Table 8.—Prices of blocks and slabs in September 1973.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Cents Per Pound											
Cod	1972 46.5	47.0	47.0	47.0	45.6	46.5	47.0	47.0	47.0	47.0	47.0	48.0
	1973 48.6	52.4	56.6	58.5	61.	66.7	68.9	71.9	78.5	80.0		
Flounder	1972 43.5	44.4	45.3	49.2	51.7	53.3	55.6	57.0	58.0	58.0	58.7	59.5
	1973 59.5	59.6	60.0	60.0	60.0	62.0	63.0	65.3	67.8	68.0		
Haddock	1972 47.1	47.5	47.5	47.9	50.3	52.8	54.4	47.0	58.1	59.5	59.5	59.5
	1973 60.1	60.5	61.4	63.3	64.9	69.0	73.3	75.5	79.6	82.3		
Ocean perch	1972 38.5	38.5	38.7	39.5	39.5	39.8	41.6	45.0	48.0	48.3	49.4	49.5
	1973 51.2	53.1	53.9	54.0	54.8	53.9	54.0	65.7	66.7	67.0		
Pollock	1972 32.3	32.0	32.0	32.1	31.2	31.5	31.5	31.0	29.6	29.5	28.3	28.0
	1973 29.0	30.1	33.0	34.0	35.2	39.8	43.1	46.0	51.2	55.0		
Whiting	1972 33.0	33.5	33.0	33.0	33.2	33.2	31.5	31.5	31.5	32.0	34.1	34.5
	1973 34.6	35.8	37.5	37.5	37.5	39.4	41.1	42.6	48.4	50.4		
Wolffish	1972 49.3	50.0	50.0	50.0	50.3	50.5	51.0	51.5	51.3	51.0	51.0	51.0
	1973 57.0	50.0	54.5	52.0	52.0	52.0	52.0	—	61.8	63.5		

Table 9.—Supplies of fish sticks and portions in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan-Sept 1973	Jan-Sept 1972	Percent change
	Million Pounds				Percent	Million Pounds		Percent
Beginning inventory	31.6	28.2	26.8	21.6	+24	34.4	23.2	+48
Production								
Sticks	7.7	9.3	10.0	9.7	+ 3	64.6	81.3	-21
Portions	21.0	27.5	26.3	23.9	+10	147.3	192.5	-24
Total	28.7	36.8	36.3	33.6	+ 8	211.9	273.8	-23
Imports	0.1	0.1	0.1	0.1	—	1.3	1.2	+ 8
Total supply	60.4	65.1	63.2	55.3	+14	247.6	298.2	-17
Ending inventory	28.2	26.8	24.7	23.5	+ 5	24.7	23.5	+ 5
Consumption	32.2	38.3	38.5	31.8	+21	222.9	274.7	-19

Table 10.—Weekly average wholesale prices of fish sticks and portions in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
<i>Cents per pound</i>								
Cod portions	67.0	67.0	69.3	60.5	+ 14	65.9	59.2	+ 11
Haddock	72.0	72.0	74.3	65.0	+ 14	70.4	63.9	+ 10
Cod sticks	87.0	87.0	89.8	77.0	+ 17	81.3	75.5	+ 8
Haddock sticks	¹	¹	88.0	79.2	+ 11	81.1	77.7	+ 4

¹ No quotes during July or August 1973.

Table 11.—Shrimp supplies in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
<i>Million Pounds</i>								
Beginning inventory	51.6	52.3	47.6	88.2	- 11	92.7	69.9	+ 33
Landings								
Total	26.7	24.3	24.9	22.5	+ 11	158.7	177.5	- 11
Gulf	14.5	9.7	10.3	15.3	+ 33	77.6	109.3	- 29
Northeast	0.6	0.4	0.4	.3	+ 33	11.2	13.3	- 16
Pacific	10.0	12.3	10.9	4.2	+ 160	60.8	44.6	+ 36
South Atlantic	1.6	1.9	3.3	2.7	+ 22	9.1	10.3	- 12
Imports	17.0	18.6	18.3	19.1	- 4	154.2	181.8	- 15
Total supply	95.3	95.2	90.8	129.8	- 30	405.6	429.2	- 6
Ending inventory	52.2	47.6	53.8	88.6	- 39	53.8	88.6	- 39
Exports								
Total	3.1	3.3	3.2	2.1	+ 52	38.6	26.1	+ 48
Domestic fresh and frozen	2.7	2.9	2.8	1.6	+ 56	29.2	21.6	+ 35
Transshipments	0.4	0.4	0.4	0.3	+ 33	9.4	4.5	+ 109
Gulf canned pack	2.1	0.6	1.4	1.5	- 7	14.8	20.7	- 28
Fresh and frozen								
Consumption	37.9	43.7	32.4	37.6	- 14	298.4	293.8	+ 2

Table 13.—Scallop supplies in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
<i>Thousand Pounds</i>								
Beginning inventory	3,029	3,554	3,655	1,686	+ 117	3,736	1,585	+ 136
Total landings	700	450	500	491	+ 2	4,845	5,114	- 5
Imports	1,780	2,002	1,938	2,281	- 15	15,318	14,465	+ 6
Total supply	5,509	6,006	6,093	4,458	+ 37	23,899	21,164	+ 13
Ending inventory	3,554	3,655	3,677	2,552	+ 44	3,677	2,552	+ 44
Consumption	1,955	2,351	2,416	1,906	+ 27	20,222	18,612	+ 9

Table 15.—American lobster supplies in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
<i>Thousand Pounds</i>								
Maine landings	1,425	2,738	3,001	3,444	- 13	10,406	9,589	+ 9
Imports	3,267	1,877	1,346	1,518	- 11	21,472	24,196	- 11
Consumption	4,692	4,615	4,347	4,962	- 12	31,878	33,785	- 6

Table 17.—Spiny lobster tail supplies in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change	Jan- Sept 1973	Jan- Sept 1972	Percent change
<i>Million Pounds</i>								
Beginning inventory	7.5	6.7	6.8	8.7	- 22	8.9	4.7	+ 89
Imports	2.0	2.5	2.6	2.7	- 4	24.7	28.9	- 14
Total supply	9.5	9.2	9.4	11.4	- 18	33.6	33.6	-
Ending inventory	6.7	6.8	7.0	9.4	- 26	7.0	9.4	- 26
Consumption	2.8	2.4	2.4	2.0	+ 20	26.6	24.2	+ 10

year, were drawn down rapidly as a result of the smaller supplies received. By the end of the month they were 26 percent below the same date in 1972. In spite of the lower quantity available, consumption rose 20 percent during September. The sharp increase in cold-water tail prices would normally be expected to lower consumption; however, the 85-cent increase this month (Table 18) apparently did not significantly reduce demand.

Table 12.—Shrimp prices in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change
<i>Dollars Per Pound</i>					
Ex-vessel					
15-20 count	2.24	2.51	2.75	1.71	+ 61
31-35	1.77	2.14	2.21	1.38	+ 60
51-65	1.42	1.66	1.64	0.96	+ 71
Wholesale					
15-20 count	2.38	2.75	3.00	1.96	+ 53
31-35	1.98	2.31	2.46	1.61	+ 53
51-65	1.58	1.76	1.86	1.10	+ 69
Retail					
15-25 count	2.94	3.13	3.57	2.99	+ 19
31-42	2.49	2.73	3.03	2.09	+ 45

Table 14.—Scallop prices in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change
<i>Dollars Per Pound</i>					
Ex-vessel	1.48	1.98	2.00	2.24	- 11
Wholesale	1.63	—	2.20	2.39	- 8
Retail	2.80	2.51	2.84	2.78	+ 2

Table 16.—American lobster prices in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change
<i>Dollars Per Pound</i>					
Ex-vessel	1.46	1.50	1.13	0.86	+ 31
Wholesale					
2 lb	2.16	2.81	2.82	2.28	+ 24
1½	2.16	2.78	2.74	2.19	+ 25
1¼	2.16	2.72	2.60	1.94	+ 34
1½	2.12	2.68	2.55	1.86	+ 37
chix	2.12	2.66	2.48	1.81	+ 37

Table 18.—Spiny lobster tail wholesale prices in September 1973.

	July 1973	Aug 1973	Sept 1973	Sept 1972	Percent change
<i>Dollars Per Pound</i>					
Wholesale price					
6-8 oz tail					
Cold-water	4.88	4.85	5.70	4.28	+ 33
Warm-water	4.00	4.21	4.14	3.65	+ 13

"Salt-Walkers"; Summing Up '73

• Ever since I first heard of them, *Halobates*, those widespread creatures of the air-sea interface, have intrigued me. How wingless insects about half an inch long can survive among—possibly thrive upon—the vicissitudes of the open sea is very curious.

Thus I was pleased to receive Lanna Cheng's paper on *Halobates* (the word, by the way, is a combination of the Greek words "hal," meaning salt, and "bates," walker). The photographs, particularly the extraordinary one that appears on the cover, were an unexpected plus—lagniappe, as they say in Louisiana.

Lanna Cheng is on the staff of the Scripps Institution of Oceanography. I worked at Scripps for several years. Looking back, it seems to me that scarcely a day passed that I did not learn something new and interesting about the ocean and its creatures. I hope that this article from Scripps awakens in you some of that same sense of wonder. It did to me.

• As these notes are being written, we are sending the December (index) number of *Marine Fisheries Review* to the printer. I am speculating, as I always do at this time, which of the seven signed articles is likely to elicit the widest response. Will it be all—or one—of the three on kamaboko? Or the new comparative studies on the chemical and nutritive values of several commonly eaten finfish and shellfish? Or the paper on squids? With the appearance of the December number, we shall have printed 67 signed articles in 1973. Some aroused more interest than I had foreseen (some aroused less, too). It was easy to predict that the "shrimp number" (March-April) might be widely read, but I did not expect all the copies to disappear in a matter of days, which they did. Nor had I anticipated the number of

requests for it that we received from abroad. In the May-June number, Tsuyoshi Kawasaki's article on skipjack tuna resources kicked up immediate interest, as did Bill Folsom's brief account of the Japanese eel fishery. Ralph Hile's classic paper on the structure and senses of fishes was in predictable demand.

In July, Erwin Penn's article on the price spread of fish products among producers and distributors spurred interest. The paper on "beefish" patties by Fred King and George Flick has been referred to many times in the trade and popular press. Louis Ronsivalli tells me that the paper on the slide rule for predicting the shelf life of cod brought requests not only for the paper but also for the slide rule. (I understand that as a result of the publication of the paper, the slide rule is now being produced in plastic, for practical use.) August brought the paper by Fred Bell and Richard Fullenbaum on the American lobster fishery: there was much interest in that, as there should have been. Processors were eager to obtain copies of Fred King's report on improving minced blocks for the fish stick trade. In September, Joe Pileggi's "Fuel shortages and the fisherman" was found useful and painfully timely.

October's three papers on Pacific salmon for New England fisheries were apparently widely read, as was the account of the alteration of the estuaries of south Florida by William N. Lindall, Jr. The November number was hardly off the press before we received calls concerning the paper on the San Francisco Bay Area herring by Maxwell B. Eldridge and W. Michael Kaill. John Dassow and Maynard Steinberg's paper on aquaculture appears to have been widely read.

To list these papers is not to single them out as "best of the year" or to

imply that the other articles we published were not equally worthwhile. But these papers (none of them "popularized" in an effort to spark wider interest, by the way) for various reasons appear to have reached a wider readership than others. Looking through them, I am struck by the fact that they range from economics to basic biology to technology to marketing. That they covered so wide a spectrum indicates the breadth of interest of the fisheries community, I suspect.

• What promises to be an interesting conference is coming up in March. From the 20th to the 22nd, in Houston's Astroworld Hotel, the Texas Coastal and Marine Council, Texas A&M University's Center for Marine Resources, and the National Marine Fisheries Service will sponsor the first international conference to explore artificial reef construction and its use.

Informal panel discussions, designed to provide for maximum sharing of information, opinions, and ideas, will focus on artificial reefs around the world; scientific aspects; materials and methods of construction; and physiological, economic, and legal considerations. Exhibits, including models, films, and the like, will be on display during the meeting.

A telling example of what an artificial reef can mean economically to a nearby community was given by Chester C. Buchanan in his paper, "Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina," which appeared in the September number of *Marine Fisheries Review*.

• Lately, we have noticed that articles from *Marine Fisheries Review* have been picked up and reprinted in other publications. For the record we welcome such a practice and are pleased that the material is of sufficient interest to reach a wider audience.

T.A.M.

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